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CAT ARM HYDROELECTRIC DEVELOPMENT: ENVIRONMENTAL IMPACT STATEMENT

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CAT ARM HYDROELECTRIC DEVELOPMENT: ENVIRONMENTAL IMPACT STATEMENT

Newfoundland and Labrador Hydro
Environmental Services Department
December 1980

Additional Copies of this report can be obtained from:

B. W. Bursey
Newfoundland and Labrador Hydro
Environmental Services
5th Floor; Philip Place
St. John's, Newfoundland
737-1206

Department of Consumer Affairs
and Environment
Elizabeth Towers
Elizabeth Avenue
St. John's, Newfoundland
737-2562

EXECUTIVE SUMMARY

Newfoundland and Labrador Hydro has identified the need for a new source of generation to be available in the autumn of 1984 to supply the growing electric energy demand of the Island of Newfoundland.

While the long-term supply solution to the growth in electricity demand is an interconnection with Labrador hydroelectric sources, this interconnection cannot be available in time to meet the projected deficit. The Cat Arm Project represents the only remaining Island based hydroelectric development of sufficient size to bridge the gap. The alternative is an oil-fired steam electric generating unit added to the existing facility at Holyrood.

The proposed Cat Arm Development is located on the Great Northern Peninsula and drains into White Bay. The Project will anually produce 597,000,000 kilowatt-hours of energy and have a capacity of 127 megawatts. The Project is expected to have a capital cost of approximately $300 million. Earth filled dams will be used to create a reservoir with a total surface area of approximately 5500 ha. The powerhouse will be located on the coast at Devil Cove, and will contain two turbine/generator sets each rated to produce 63.5 MW. Access to the project will be by means of a gravel road from Jackson's Arm. The plant will be interconnected with the grid system by means of a single 230 KV line to Corner Brook. The project will be constructed over 43 months. The work force will peak at about 600 men and will require a total of approximately 13,000 man months of labour.

A variety of environmental studies have been undertaken on the Cat Arm Project since 1975. These studies have contributed to the final project definition, and form the data base upon which this Environmental Impact Statement is based. A total of 13 different environmental studies have been completed by Newfoundland and Labrador Hydro at a cost of approximately $280,000.

The project area has an unstable climate characterized by rapid changes in weather conditions. It has one of the coldest climates on the Island and has relatively high precipitation. The watershed is characterized by glacially smoothed and scoured bedrock. The hills and valleys are generally devoid of overburden.

The Cat Arm Development is located on an uplifted fault block forming a plateau with an elevation of approximately 518 m in the vicinity of the Cat Arm dam site. The peneplain is highly dissected, hilly, rugged and barren. It drops percepitiouslyapproximately 300 m to the ocean in the area of Devil Cove. The project area consists of unlicenced Crown Land and does not include any mineral development.

The hydrology of the Cat Arm River is characteristic of the fluctuations found in an unregulated upland water course in Newfoundland. Minimum flows are less than 3 m^3/sec and occur in winter; the peak runoff (280 m^3/sec) occurs during the spring snow melt in April and May. The mean discharge at the main dam site is 26.3 m^3/sec. The lake systems within the Cat Arm watershed are all quite shallow with bedrock or boulder bottoms. At peak flows, the water within these lakes is totally exchanged within a few hours. In part because of rapid surface runoff and the short contact time between water and the surface material, waters of this area are very soft and low in the nutrients, but with an extremely low pH (approximately 4.6) and this latter factor may be limiting to the success of brook trout.

Great Cat Arm is a typical fjord with a V-shaped profile and a sill at its mouth. Devil Cove is a U-shaped indentation along the coastline and is essentially marine in nature.

The plankton biomass present in Cat Arm Lake and surrounding ponds is very low and consists of a limited number of species. The area can be described as oligotrophic. Great Cat Arm is a typical estuary with limited mixing and contains species common to an estuarine environment. Species found in the Devil Cove area are typically marine.

The fish of the Cat Arm watershed include brook trout (freshwater and sea run), Atlantic salmon, and American eel. Only the freshwater brook trout occurs in the watershed above a barrier falls near the river mouth. The brook trout occur throughout the system with groupings isolated by various barriers. Both the numbers of fish, and the maximum size attained are quite modest, so that the sport fishery potential is insignificant. The sea run brook trout and Atlantic salmon populations at the mouth of the river are very minor, consisting of a run of approximately 20 adult salmon, and a stock of 200 sea run brook trout. Because of the extent and severity of obstructions on the main river, there is little practical potential for enhancement programs to expand this population.

The Cat Arm watershed is relatively well vegetated with Fir-Spruce Woodland, Scrub and Wetlands (mostly bogs). True Forests do not occur. Woodlands occur in sheltered valleys and basins, and comprise 35% of the proposed reservoir area. Scrub transitions occur between Woodlands and Wetlands, and also on the border of Tundra-Barren communities. The area contains some potentially productive timber. It is estimated that "merchantable stands" comprise 220,000 cubic meters (91,000 cords) of pulpwood. Of this it is estimated that approximately 1/3 would be cull wood.

Waterfowl breeding populations in the area are relatively low and the area is not on any major migration routes. Species observed included Canada Geese, Black Ducks, and Merganser.

Approximately 17 mammal species are reported to occur in the study area. The most important game species is moose. The area has one of the highest moose populations (1.02 moose per km^2) on the Island. Despite this, lack of access has meant that the moose population is underharvested. An extensive survey was conducted to locate caribou and identify their pattern of land use. Two groups, the Humber Herd and the Northern Peninsula Herd (350 and 1100 animals respectively) have a range that includes the study area Results of aerial surveys confirm earlier reports that the Cat Arm watershed area is not heavily utilized. Caribou tend to overwinter along the western edge of the Long Range Mountains; fall and spring occurrence may include some areas to the south of the Cat Arm watershed; and summer range, when the animals are dispersed, may include the Cat Arm watershed. During the periods of densest aggregation, and highest sensitivity (rutting, and calving respectively) the animals are well outside the project area, and major migration routes do not include the Cat Arm watershed. Recent increases suggest that the Northern Peninsula Herd is growing in size.

Aquatic and terrestrial furbearers occur in the project area but are limited in numbers. Consequently (and as well because of limited access) hunting and trapping does not occur within the project area.

The human population of the study area was examined in considerable detail, with emphasis on the communities of Jackson's Arm, Sop's Arm and Hampden (those closest to the proposed development). Employment opportunities are, in general, at a premium and many tend to be seasonal in nature. In recent years there has been an increased participation, particularly by women in the labour force. Fishing, logging, and service industries are the major employers in the area. With recent improvements in the fishery, the trend since 1976 has been toward an increase in participation rate and a decrease in the unemployment rate.

With the growth in economic activity related to the fishery, a critical housing shortage is developing in the Jackson's Arm/Sop's Arm area. The need for municipal planning and servicing is acute in these communities, whether or not the Cat Arm Development proceeds. An attitude survey conducted among residents of the project area revealed a major concern for employment opportunities and a willingness to accept environmental impacts identified with hdyroelectric development. Strong objections to the development were not raised during public meetings nor expressed during the attitude survey. Interest was expressed about employment opportunities and the spinoff benefits which would accrue to the region from such a development.

The purpose of this entire exercise is to produce a prediction of impacts from which appropriate mitigation strategies can be identified, and with which judgements can be made about the environmental acceptability of the proposed action. The major impacts (and proposed mitigations) can be summarized as follows:

1. An estimated 355,000 m^3 of impervious glacial till and 610,000 m^3 of sand and gravel will be required during construction of the project. This will result in changed geomorphology and local drainage patterns which commonly induce erosion. Borrow areas will be located where possible within the reservoir area. Other borrow sites have been eliminated because of environmental sensitivity (for example, Coney Arm River). Post-construction borrow pit rehabilitation practices will reduce the asthetic impacts of these pits and encourage stabilization of the disturbed areas.

2. Stands of merchantable timber exist within the future reservoir area and have been estimated to be approximately 91,000 cords. At present the forestry resource of the Cat Arm area is not of commercial interest due to lack of access. Much of the wood is located in scattered pockets or on difficult terrain and is of low quality. The construction of access roads will increase the potential for forestry utilization in the area. Where economically feasible, the forest resource will be harvested and removed from the reservoir area.

3. Reservoir formation will alter the existing system by increasing surface area as well as depth,

decreasing shoreline length and decreasing the flushing rate of water. As well, an altered drawdown regime will create a stress on the productivity of the shoreline zone. The net effect of these changes will be toward a slight increase in plankton productivity. This will be augmented by the mild surge in productivity which accompanies the release of nutrients from the terrestrial zone that is flooded during reservoir formation.

4. The increase in aquatic habitat will be approximately six times greater than the combined surface area of all the existing lakes and ponds. The quality of this habitat for brook trout productions is much less than that of the existing lakes, however the net effect will probably be an increase in potential yield in the order of three times that of the present level. As well there will probably be a shift in size composition towards somewhat larger fish. Nevertheless, some limitation may be introduced by the reduction in stream habitat. Monitoring surveys will be conducted to ascertain whether this does occur and to identify strategies (such as blasting at falls) to provide such habitat if it is needed. Even with the potential for an increase in production and average size, there does not appear to be potential for a sport fishery within the project area.

5. The flow down the Great Cat Arm River will be significantly reduced. At its mouth the river will have recovered approximately 20% of its previous flow. During project operation, spill will occur down the river only three months of the year (May, June, and July) during most years.

The major impact of this flow reduction will be to degrade the habitat for the small run of salmon and sea trout that utilizes the mouth of the river. It is proposed to construct a weir facility at the mouth of the river to ensure maintenance of the most valuable stream habitat. This will reduce the impact of waterflow reductions.

6. The project will result in the diversion of waterflow by greatly reducing the input to Great Cat Arm and increasing the freshwater input to Devil Cove. No major negative impacts of the diversions are predicted for the Great Cat Arm area. The only major change will be an increase in the abundance of shore zone life forms as organic loading of the bottom by river inflow decreases. At Devil Cove the increased freshwater flow will dramatically alter much of the intertidal and subtidal marine biota. A minor increase in plankton may be reflected in an increase in abundance in planktivorous fish species. This effect will be minimal if it does occur.

7. The loss of terrestrial habitat is the most significant impact on wildlife. During construction, the effects of human activity will produce a negative but transient impact. The reservoir will flood ungulate and small mammal habitat, but no critical areas. The access road routing has been selected to avoid caribou wintering areas and other sensitive terrain features. It is highly unlikely that caribou migration will be affected by the project. The impact on moose will result from habitat loss and increased access. Reservoir formation will remove winter range and produce a consequent reduction in the total carrying capacity of the area.

Increased access will result in greater hunter pressure and greater hunting success. This will result in an increase in the utilization of this resource.

8. Construction activities will require 1300 man years of labour over the 43 month construction period. Only a small percentage of the labour force will come from the immediate area, and a strain will be placed on existing facilities. This will be partly overcome by the provision of work camp and other service facilities at site as well as in the community of Jackson's Arm. Employment during operation of the facility will be small but will represent a permanent contribution to the local communities. The completion of the access road and implementation of a policy to make it available for public use will present some opportunities for long-term employment associated with natural resource utilization.

9. The Cat Arm Project area represents an unexploited wilderness region that possesses some dramatic and impressive scenery. While the implementation of the project will inevitably alter its wilderness character, the opening up of access will enable greater numbers of people to view this scenic area. As well, the project itself does not represent a severe alteration in the landscape. The shoreline will be clear cut; the penstock will be underground; and access road and transmission line routing have been planned to minimize negative effects.

Newfoundland Hydro has established on the basis of these and other studies, the technical and economic feasibility of the Cat Arm Hydroelectric Development. On the basis of its program of environmental studies there has not been identified any major negative environmental impact which would prevent this project from proceeding. Further, strategies have been identified which will minimize negative impacts, and enhance positive impacts so that maximum benefit will be attained by the Province from the implementation of this project as described in the Environmental Impact Statement.

FOREWORD

The Newfoundland and Labrador Hydroelectric Corporation (Hydro) is the body responsible for meeting the electric power generation and transmission requirements of the province. In fulfilling this obligation, Hydro has adopted a policy of according due regard to protection of the environment. In the implementation of this policy, Hydro has established an Environmental Services Department which acts to provide policy guidance and technical advice to the Hydro group of companies. A major activity of this department is the determination of the environmental feasibility of candidate projects. For major projects, this usually entails the production of an Environmental Impact Statement. This present exercise represents the fourth Environmental Impact Statement produced by the Hydro group of companies, so that the process has become firmly established within our organization, and has, we feel, proven to be a most useful tool in our planning process, and perhaps more importantly, a critical element in the exercise to identify actions which are to the maximum benefit of the Province.

In 1980 the Government of Newfoundland and Labrador took a major step by passage of legislation requiring Environmental Impact Assessments for actions which could have a significant effect on the environment. Thus, what had heretofor been policy has now become fixed in law. Hydro welcomes this strong affirmation of the province's commitment to protection of living renewable resources and the "quality of life".

Prior to the formal submission of an Environmental Impact Statement, Hydro endeavours to make its own determination on the environmental acceptability of a project. This document is therefore submitted on the basis that a decision has been made by the proponent that the proposed action can be undertaken with a minimum of environmental disturbance and in a manner that is acceptable to the Province.

December 1980

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As well, the assistance of the volunteer citizens committee of Jackson's Arm - Sop's Arm under the chairmanship of Mr. Lloyd Smith has insured the input of local resident's concerns within this planning exercise.

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    Lands Division

Department of Tourism
    Historic Resources Division
    Wildlife Division
    Parks Division

Department of Mines and Energy
    Mineral Development Division
    Environmental Geology Section

Federal Government

Environment Canada
    Canadian Forestry Service
    Canadian Wildlife Service
    Environmental Protection Service
    Department of Fisheries and Oceans
Parks Canada

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Finally, the Senior Management of Hydro wishes to acknowledge the key role played by Bruce W. Bursey, Senior Ecologist - Assessments whose responsibility it was to manage the various study contracts and draft the Environmental Impact Statement.

1. INTRODUCTION

This document is an Environmental Impact Statement (EIS) relating to the Cat Arm Hydroelectric Development proposed by Newfoundland and Labrador Hydroelectric Corporation (Hydro). The impact assessment was done as a matter of policy by Hydro in accordance with the Provincial "Environmental Assessment Act" as administered by the Department of Consumer Affairs and Environment (DCEA).

The purpose of this assessment is to predict and evaluate possible impacts of the proposed Development when examined in the context of the predevelopment environment, and to propose practicable mitigating measures to eliminate or reduce negative impacts and enhance positive impacts. The EIS is intended to aid the Minister of Consumer Affairs and Environment in evaluating the environmental acceptability of the proposed Development and to inform the public of the proposed undertaking.

The environmental assessment of the Cat Arm Development began in March, 1975. At that time Hydro informed DCAE that four hydroelectric developments were being considered as generation options. These were Upper Salmon, Cat Arm, Terra Nova and the Upper Lloyds River Diversion. The DCAE formed an Environmental Assessment Committee for Hydroelectric Projects (then called the Power Development Advisory Committee). The Assessment Committee immediately retained Beak Consultants Ltd. and Airphoto Analysis Associates, at Hydro's expense, to conduct a preliminary assessment of the environmental impacts of the four developments, and to recommend further studies necessary to obtain sufficient information to complete future environmental impact assessments. The Lloyds River Diversion and Terra Nova Development were subsequently withdrawn from the preliminary assessment.

The consultant report entitled Upper Salmon/Cat Arm Environmental Impact Assessment (Preliminary) was completed in September, 1976. Based on the conclusions of this report the Assessment Committee identified the need for further studies to address specific environmental concerns. Between the period 1977 and 1980 twelve studies have been completed by Hydro in response to recommendation by the Assessment Committee.

Terms of reference for each of these studies have been reviewed by the assessment Committee and approved by the Minister of DCAE. All the environmental and socio-economic reports have received extensive review by provincial government agencies under the co-ordination of the Assessment Committee Chairman. The comments received by Hydro as a result of this review were discussed with the consultants and the agencies concerned. In most cases revisions were made to the reports to clarify points and to incorporate points raised by the various agencies. Consultants were given an opportunity to prepare a rebuttal to criticisms where disagreement existed as a result of differences of professional opinion. Copies of these rebuttals are on file with Hydro's Environmental Services Department.

Copies of the final reports have been made available upon request to interested members of the public and have been forwarded to the provincial Reference Library, Memorial University of Newfoundland Centre for Newfoundland Studies and the local citizen committee representing the Jackson's Arm/Sop's Arm area.

The consultants' reports listed below contain much more detailed scientific information than appears in this EIS. What follows is an attempt to summarize the component studies into a single report that will help specialists and laypeople alike evaluate the impacts associated with the Development. Readers are encouraged to refer to the consultants' reports for specific information if it is required.

Airphoto Analysis/Beak Consultants Ltd., 1976, "Upper Salmon/Cat Arm - Preliminary Environmental Impact Assessment", Toronto, Ontario.

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F. F. Slaney and Company Ltd., 1978, "Salvage of Merchantable Timber and Clearing Proposed Cat Arm Reservoir", Toronto, Ontario.

F. F. Slaney and Company Ltd., 1979, "Cat Arm Mammal Study", Toronto, Ontario.

2. THE CAT ARM DEVELOPMENT

2.1 Development Rationale

2.1.1 The Need

The planning process in electrical utilities begins with the load forecast. A load forecast is a prediction of the amount of power (kilowatts) and energy (kilowatt-hours) which will be required at any specific point or points during a future time period on an electrical system.

Newfoundland and Labrador Hydro prepares its 20 year load forecast in the spring of each year, separately examining the energy demand requirements for each of the Province's three major classes of customers; residential, general service and industrial. Many factors are systematically considered when estimating demand. For example relative energy prices, conservation programs, income growth, appliance ownership and alternative supply and pricing scenarios are all important demand determinants.

From 1960 to 1979 electrical energy consumption grew at an average annual growth rate of 7.1 percent. However, for the 1980 and 2000 forecast period, Hydro's May 1980 load forecast predicts a 4.9 percent average annual growth rate. High real electricity prices, conservation programs, and lower population growth rates are expected to slow electricity consumption growth.

Comparing available capability with forecast power and energy shows a power deficit in the fall of 1984 and an energy deficit in 1985. Therefore, a new source of generation must be available in the autumn of 1984 to eliminate the deficit situation.

2.1.2 Alternative Energy Supply Options

The type and size of the new source to be added in 1984 depends greatly on what the long term supply of electrical energy for the Province is going to be.

Newfoundland and Labrador Hydro has studied all long term options, and interconnection with Labrador is the optimum. This interconnection cannot be available, however, by the fall of 1984 and, therefore, some intermediate on-island source is required to bridge the gap.

The following main sources are being considered to meet the deficit in 1984:

Cat Arm Hydroelectric Project	597* GWH
Holyrood No. 4 Steam Electric Generating Plant	935 GWH
Island Pond Hydroelectric Project	155 GWH

* 1 GWH - 1,000,000 kwh.

As mentioned earlier, the timing of the interconnection influences the choice of intermediate generation. For example, the shorter the delay, the better Holyrood No. 4, and the longer the delay, the better Cat Arm. No final decision can be made until the status of the environmental acceptability is known and the status of a Labrador in-feed is clarified.

2.2 Project Description

The proposed Cat Arm Development is located in the southeastern quarter of the Great Northern Peninsula on the raised uplands of the Long Range Mountains between 49° 50' and 50° 10' North latitudes and between 56° 45' and 57° 15' West longitudes. Jackson's Arm, the nearest community is approximately 25 km southeast of the proposed project area (Figure 1).

To utilize the hydroelectric potential of the Cat Arm River, the proposed Development provides for the construction of a 51.5 m high earth filled main dam at the head of the rapids section of the Cat Arm River approximately 18 km upstream of the mouth of the river. This dam will divert flows from the Cat Arm River into a main reservoir. From this main reservoir the flow will be diverted through the height of land via a forebay canal and tunnel to a forebay reservoir. The forebay reservoir will be formed by a series of four dams across low areas on the eastern rim of the Cat Arm watershed about 2.8 km from the Atlantic coast overlooking Devil Cove. From the forebay reservoir water will flow through a partially concrete lined tunnel to a surface powerhouse at the head of Devil Cove with discharge to tidewater. The powerhouse will contain two turbine/generator units having a total firm capacity of 127.0 MW. A surge tower will provide for speed regulation and protection against excessive water-hammer pressure rises.

A gated spillway capable of passing the maximum probable flood will be located in the east section of the Cat Arm Dam. A smaller overflow spillway will be located in the forebay reservoir (Figures 2 and 3).

The following sections provide a brief account of the proposed Development as described in the engineering feasibility (Shawmont, 1980 a).

2.2.1 Cat Arm Dam and Spillway

The Cat Arm Dam will be of rolled rockfilled construction with a central impervious core of glacial till sealed on cleaned, and where necessary, grouted bedrock. It will be located in the Cat Arm River immediately downstream of the first waterfall at the outlet of a series of small lakes on the head waters of the river.

The dam comprising two individual sections separated by a knoll of higher ground, will have a maximum elevation of 51.5 m above the river bed, with a crest elevation of 396 m. The west section of the dam will have a length of 533 m and will contain approximately 1,100,000 m^3 of earth fill. The east section will have a length of 335 m and will contain approximately 150,000 m^3 of earth fill.

The dam will be constructed over three construction seasons to a schedule that will provide for catchment of 15 consecutive months of runoff preceding the on-power date, October 31, 1981.

The spillway will be located in the knoll separating the east and west sections of the Cat Arm Dam. It

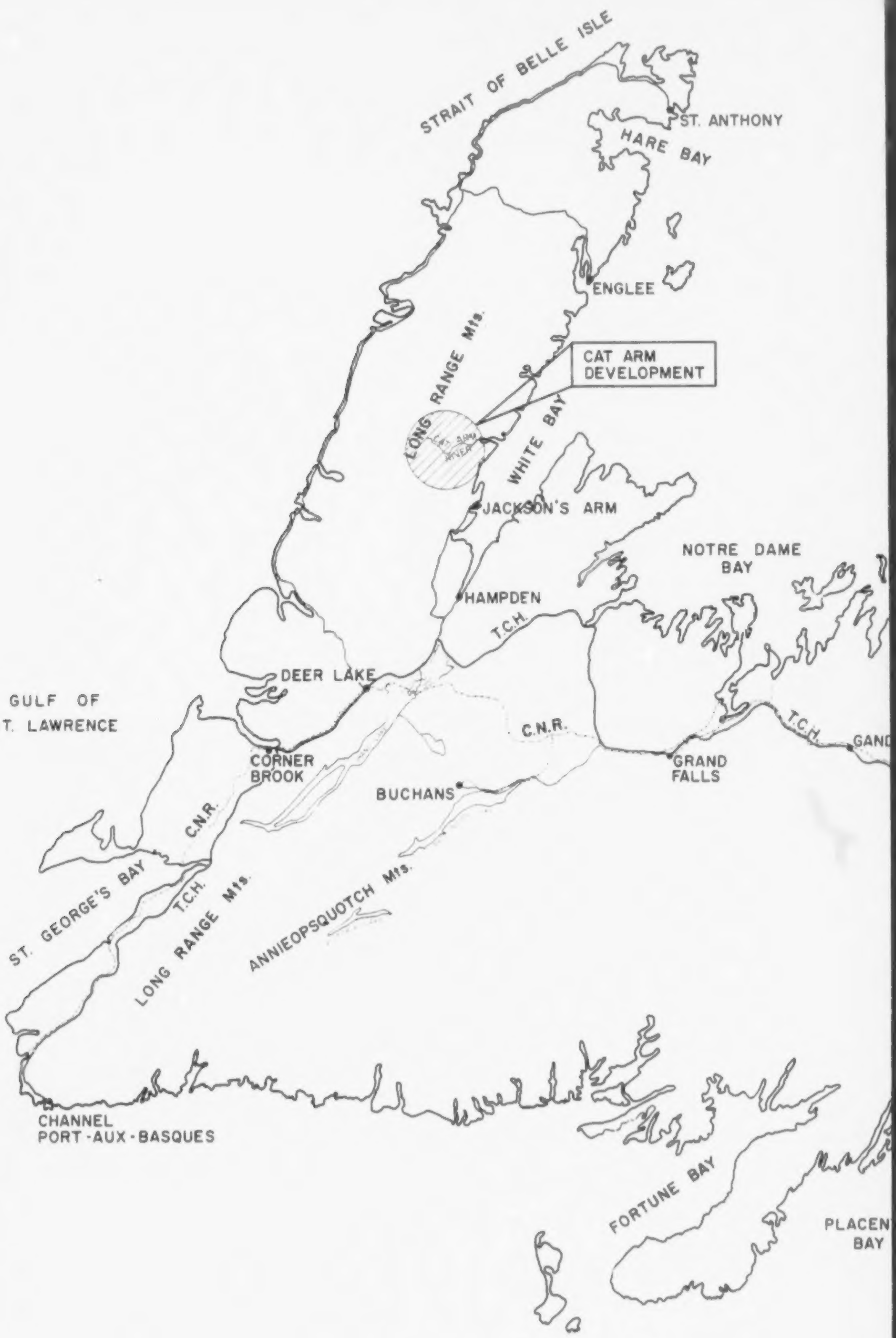
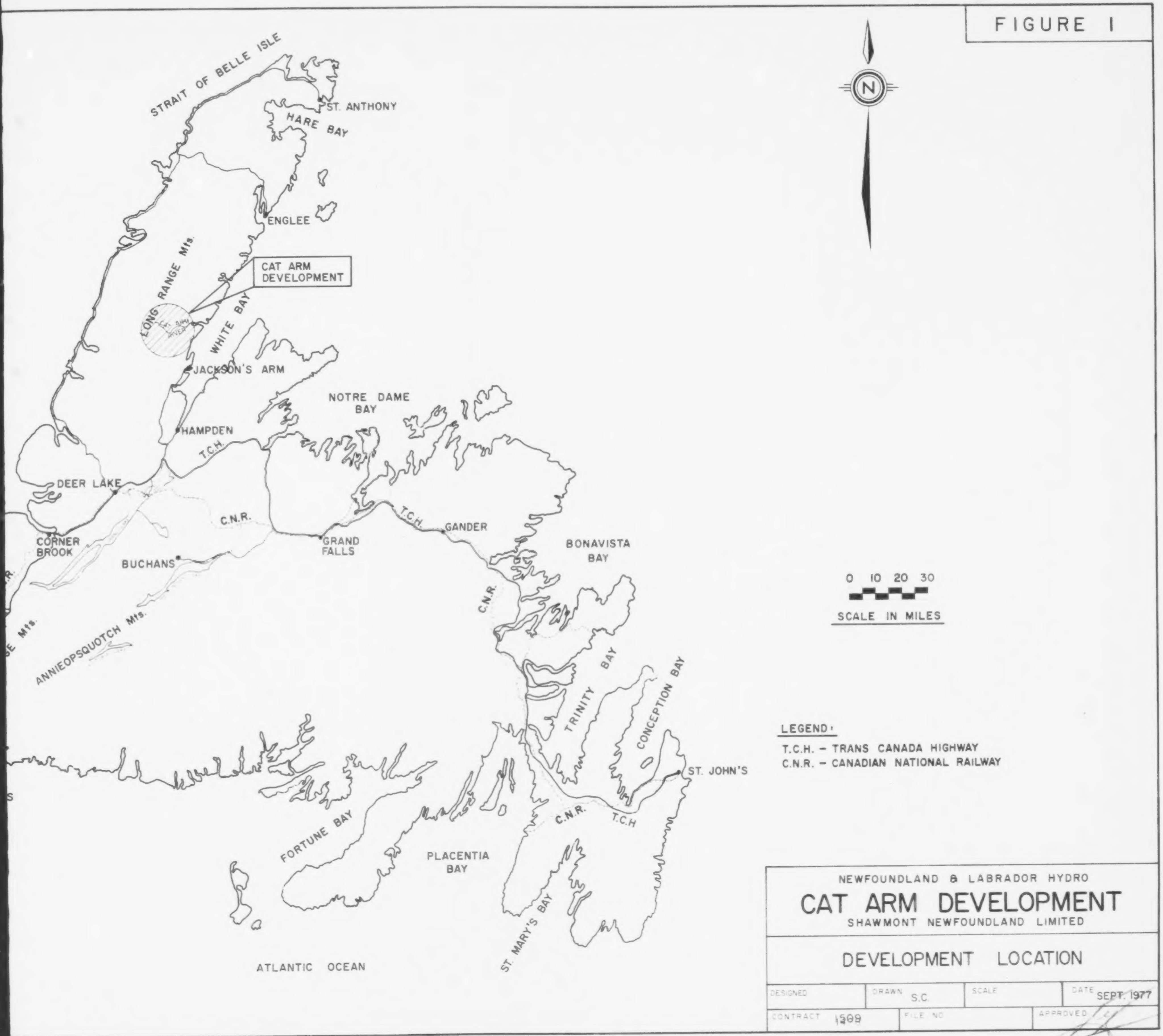

STRAIT OF BELLE ISLE
ST. ANTHONY
HARE BAY
ENGLEE
LONG RANGE Mts.
CAT ARM
DEVELOPMENT
CAT ARM
RIVER
WHITE BAY
JACKSON'S ARM
NOTRE DAME
BAY
HAMPDEN
T.C.H.
DEER LAKE
GULF OF
ST. LAWRENCE
C.N.R.
T.C.H.
GAND
CORNER
BROOK
GRAND
FALLS
BUCHANS
C.N.R.
ST. GEORGE'S BAY
T.C.H.
LONG RANGE Mts.
ANNIEOPSQUOTCH Mts.
CHANNEL
PORT-AUX-BASQUES
FORTUNE BAY
PLACEN
BAY
ATLANTIC OCEAN

FIGURE 1


STRAIT OF BELLE ISLE
ST. ANTHONY
HARE BAY
ENGLEE
LONG RANGE Mts.
CAT ARM DEVELOPMENT
CAT ARM RIVER
WHITE BAY
JACKSON'S ARM
NOTRE DAME BAY
HAMPDEN
T.C.H.
DEER LAKE
C.N.R.
CORNER BROOK
BUCHANS
GRAND FALLS
T.C.H.
GANDER
BONAVISTA BAY
C.N.R.
GE Mts.
ANNIEOPSQUOTCH Mts.
TRINITY BAY
CONCEPTION BAY
ST. JOHN'S
C.N.R.
T.C.H
FORTUNE BAY
PLACENTIA BAY
ST. MARY'S BAY
ATLANTIC OCEAN
N
0 10 20 30
SCALE IN MILES
LEGEND:
T.C.H. – TRANS CANADA HIGHWAY
C.N.R. – CANADIAN NATIONAL RAILWAY

NEWFOUNDLAND & LABRADOR HYDRO
CAT ARM DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED

DEVELOPMENT LOCATION

DESIGNED	DRAWN S.C.	SCALE	DATE SEPT. 1977
CONTRACT 1309	FILE NO		APPROVED

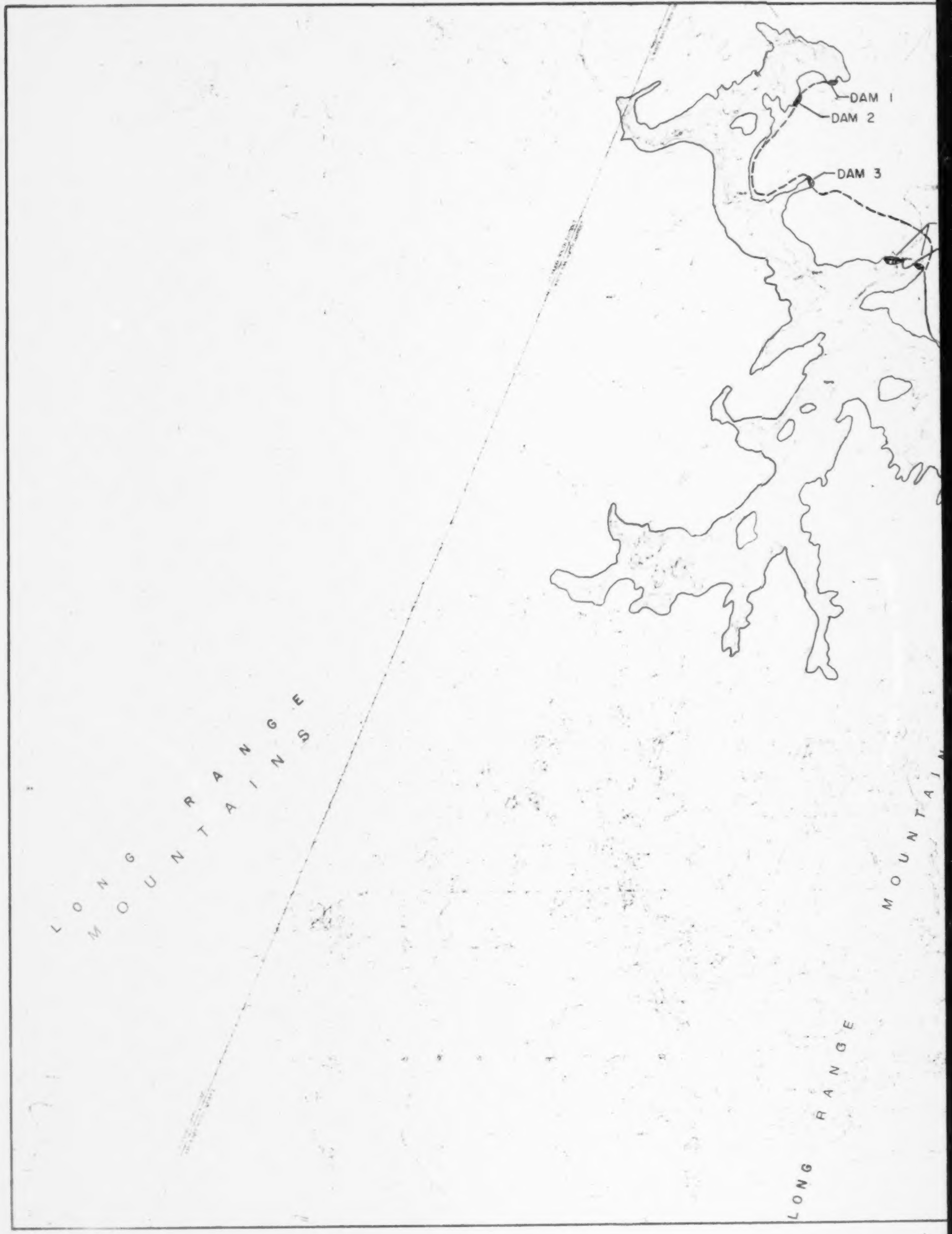
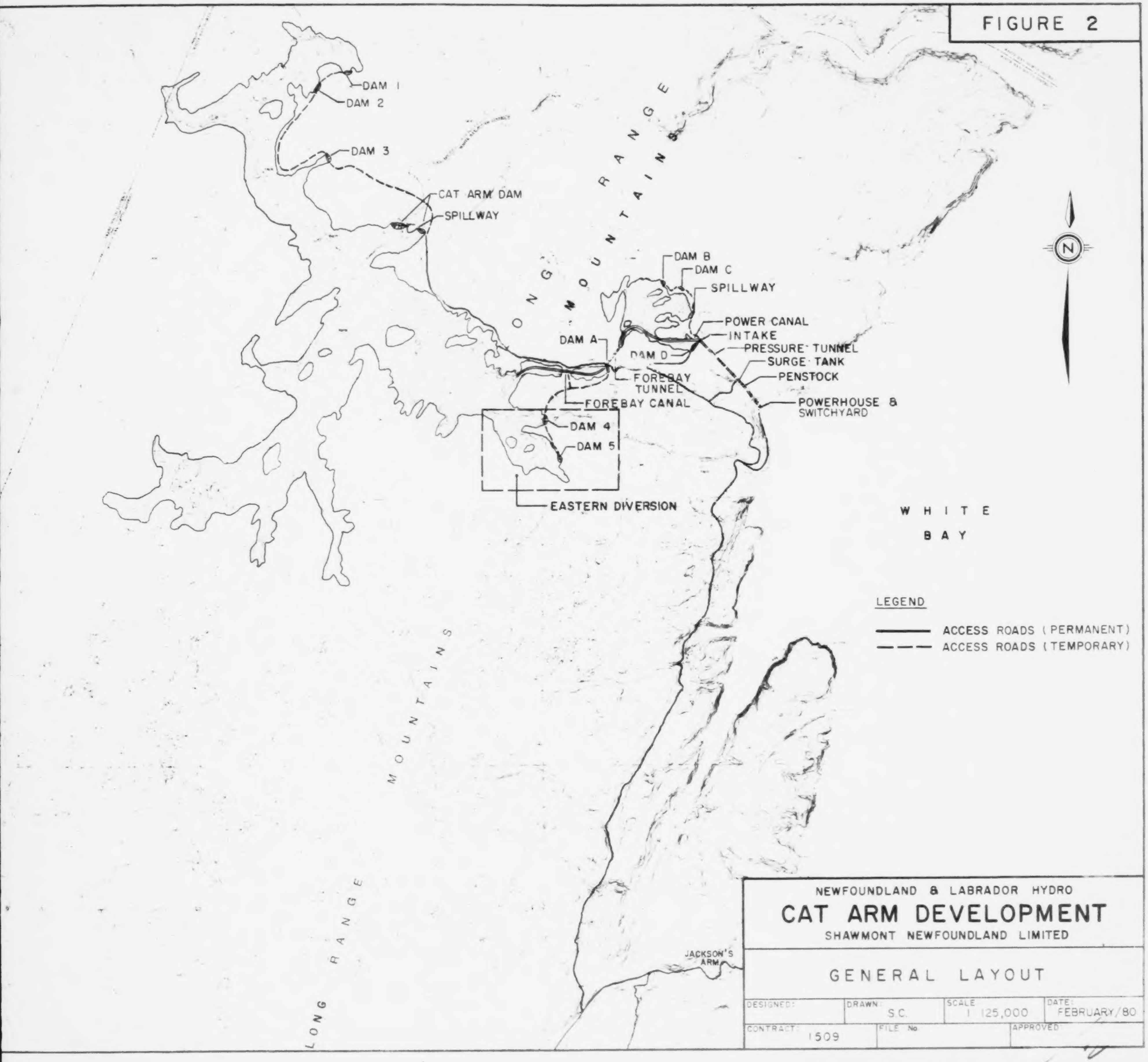

DAM 1
DAM 2
DAM 3
LONG RANGE MOUNTAINS
MOUNTAI
LONG RANGE

FIGURE 2



DAM 1
DAM 2
DAM 3
CAT ARM DAM
SPILLWAY
LONG RANGE MOUNTAINS
DAM B
DAM C
SPILLWAY
POWER CANAL
INTAKE
DAM A
PRESSURE TUNNEL
DAM D
SURGE TANK
PENSTOCK
FOREBAY TUNNEL
FOREBAY CANAL
POWERHOUSE & SWITCHYARD
DAM 4
DAM 5
EASTERN DIVERSION
N
WHITE BAY
LEGEND
ACCESS ROADS (PERMANENT)
ACCESS ROADS (TEMPORARY)
LONG RANGE MOUNTAINS
JACKSON'S ARM

NEWFOUNDLAND & LABRADOR HYDRO

CAT ARM DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

GENERAL LAYOUT

DESIGNED:	DRAWN: S.C.	SCALE 1 125,000	DATE: FEBRUARY/80
CONTRACT: 1509	FILE No.		APPROVED:

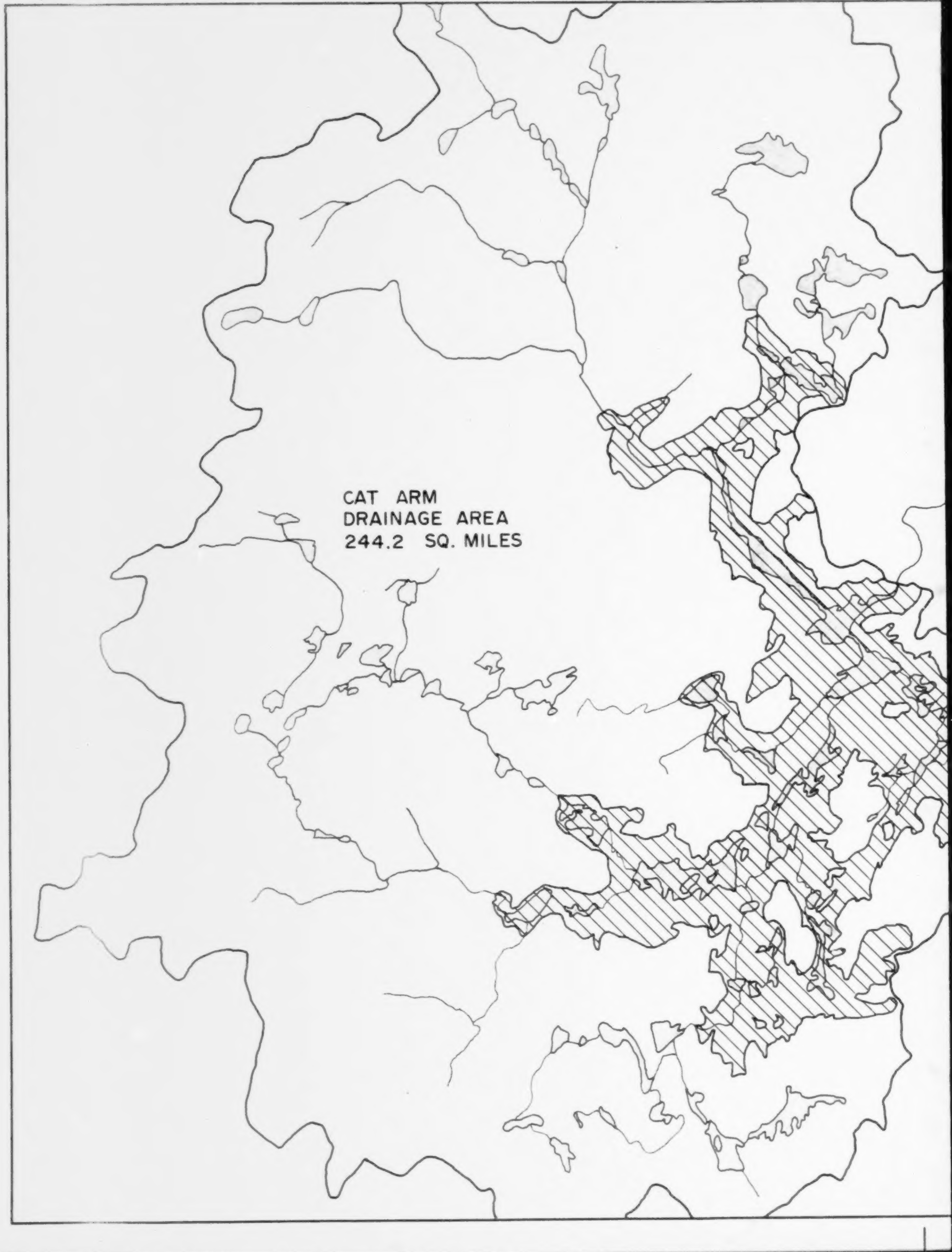
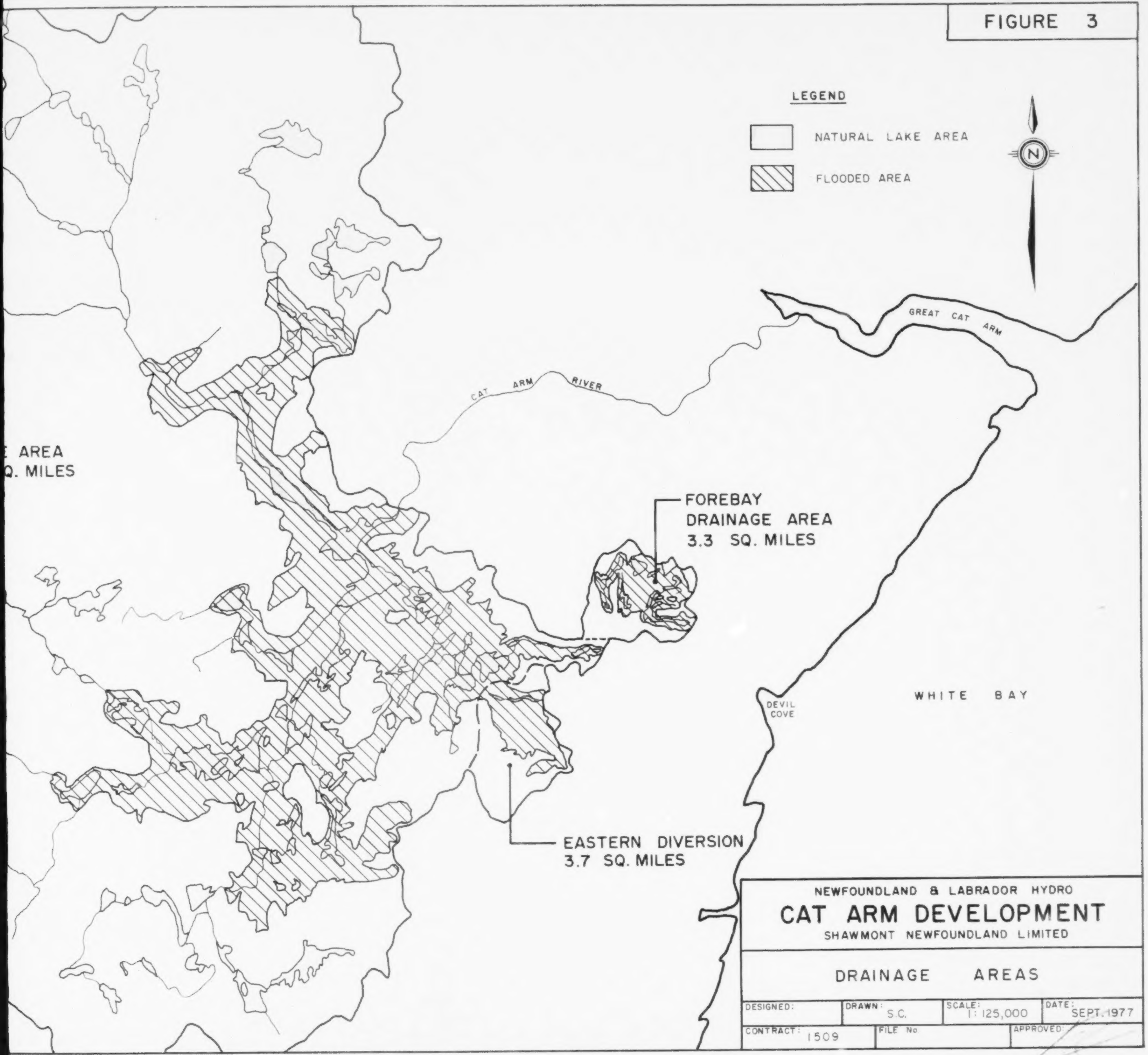

CAT ARM
DRAINAGE AREA
244.2 SQ. MILES

FIGURE 3


LEGEND
☐ NATURAL LAKE AREA
▨ FLOODED AREA
N
GREAT CAT ARM
CAT ARM RIVER
E AREA
Q. MILES
FOREBAY
DRAINAGE AREA
3.3 SQ. MILES
WHITE BAY
DEVIL
COVE
EASTERN DIVERSION
3.7 SQ. MILES

NEWFOUNDLAND & LABRADOR HYDRO

CAT ARM DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

DRAINAGE AREAS

DESIGNED:	DRAWN: S.C.	SCALE: 1: 125,000	DATE: SEPT. 1977
CONTRACT: 1509	FILE No.		APPROVED:

will discharge the spillway flow via a channel downhill into a natural lake at a level lower than the dam. The channel will involve the excavation of about 58,000 m^3 of rock and will be 58 m wide, 304 m long, and have a maximum excavation depth of 16 m.

The spillway will be a reinforced concrete structure containing about 2,752 m^3 of concrete with a sill elevation of 383 m. It will have two vertical lift gates with a total discharge capacity of 1,014 m^3/sec when the reservoir is at full supply level of 393 m.

2.2.2 Reservoir and Perimeter Dams

The Cat Arm Reservoir will be located approximately 10 km inland from White Bay. The reservoir structures will include the Cat Arm Dam and Spillway and five perimeter dams around the east side of the reservoir. These structures will effectively raise the original level of the lakes by 43 m to a full supply level of 393 m. The maximum drawdown on the reservoir will be in the order of 7.3 m to elevation 386 m. This extreme drawdown will occur only in the event of a design drought which has a probability of occurrence in any one year of about 1 percent. The average drawdown will be in the order of 1.8 meters. The total reservoir surface area will be 53,000 ha and the new water levels will flood approximately 4,300 ha of shoreline.

One of the perimeter dams will divert a river, which normally flows eastward into White Bay, back into the Cat Arm reservoir. This is called the Eastern Diversion and will increase the drainage area of the reservoir by 9.58 km^2 (Figures 2 and 3).

Three of the five dams around the perimeter of the reservoir will be located to the northwest of the Cat Arm Dam while two others will be located southeast at distance of approximately 5 and 8 km respectively from the Cat Arm Dam (Figure 2). These dams will have a crest elevation of 396 m and a total crest length of 97 m and will require approximately 300,000 m^3 of earth fill. All of the dams will be of zoned rolled rockfill construction with a central impervious core of glacial till on cleaned, grouted bedrock.

2.2.3 Forebay Canal and Tunnel

The forebay canal will be excavated 457 m through a rock saddle linking two natural valleys providing direct water flow to the forebay tunnel. The 3.3 km long canal will be in rock cut over most of its length, except where existing water levels and depths in small ponds along the canal route negate the need for excavation. Approximately 184,000 m^3 rock excavation are required. The maximum depth will be approximately 15 m and the width will be 12 m to allow for unimpeded operation of construction equipment.

The canal will be designed for a maximum flow of 39 m^3/sec at a maximum velocity of .6 m/sec with the reservoir at low supply level, including .6 m of ice cover.

The forebay tunnel will be driven from the natural valley through the rock ridge dividing the main reservoir from the forebay. The tunnel will have a 6 m x 6 m inverted "U" section and a length of 762 m. It will generally be unlined with any localized areas of poor rock supported by steel beams built into concrete lining. Inlet and outlet portals to the tunnel will be concrete faced.

2.2.4 Forebay Dams and Spillway

A series of four dams are required across low areas on the perimeter of the forebay. They will have a crest elevation of 396 m and a total crest length of 701 m. The maximum heights of the structures will vary from about 3 m to 15 m and will require approximately 113,000 m^3 of earth fill(Figure 2).

The forebay spillway will be located in a shallow valley immediately north of a forebay dam. It will discharge the spillway flow eastward into a natural streambed which will carry the water eastward into White Bay. No rock excavation is expected at this site.

The spillway will be a mass concrete structure with a maximum height of about 2 m. It will contain about 46 m^3 of concrete and will be founded on bedrock. It will be a broad crested weir with a crest elevation of 393 m, a crest length of 27 m and a discharge capacity of 33 m^3/sec with a forebay maximum flood level of 394 m.

2.2.5 Power Canal and Intake

The power canal will be located just upstream of the forebay closure dam. The canal will be approximately 3 km long and 12 m wide. Approximately 214,000 m^3 of rock excavation will be required. The canal will be designed for a maximum flow of 39 m^3/sec at a maximum velocity of .6 m/sec.

The intake will be set hard against the rock at the back of the power canal cut. It will serve as a portal for the power tunnel as well as a housing for the intake closure gate. Closure will be effected by means of a wheeled main gate with a standby slide gate for servicing and emergency use. Removable trash racks will be located on the upstream intake face. Operation of the main gate will be by an overhead rope hoist and that of the racks and emergency gate by means of a mobile crane.

2.2.6 Power Tunnel

The power tunnel will consist of a low pressure tunnel and a penstock tunnel driven at varying depths (46 m to 200 m below surface level) and a vertical shaft to the surge tower.

The tunnel will be approximately 2.8 km in length, circular in cross-section with a diameter varying from 3 m to 6 m. The upper 30 m of the vertical shaft and the downstream 274 m section of the penstock will be steel lined; the remainder will be mass concrete lined. Approximately 79,000 m^3 of rock will be excavated from the tunnel and vertical surge tower shaft.

2.2.7 Powerhouse and Tailrace

The powerhouse will be located on the west shore of Devil Cove where it will be set back into an open rock cut at the foot of an approximately 24 m high benched rock face. Enclosed within the powerhouse will be two turbine/generator sets each rated to produce 65 MW of power. The main power transformers and switchyard will be located outside and to the north end of the main building. A special freshwater reservoir will be constructed to provide fire protection and water for start-up.

The tailrace will be excavated through the beach on the west side of Devil Cove. It will be 137 m long open channel with a trapezoidal cross-section 7 m wide at the bottom and will have a maximum depth of 15 m.

2.2.8 Access and Transmission

An all weather gravel road will provide access from Jackson's Arm to the powerhouse, the switchyard and the main dam. Temporary roads will be constructed to provide access to the smaller perimeter dams and to borrow areas to be located within a 10 km radius of the various structures. The total length of access road required for the project is estimated to be in the order of 85 km with approximately 40 km of this being permanent road (Figure 2).

It will be necessary to initially construct the main access road on three fronts; two starting at Little Coney Arm and the other at Jackson's Arm. At Little

Coney Arm the work will start from the beach head with the contractor maintaining operation by sea or air. At Jackson's Arm, it will be necessary to construct a bridge over the Coney Arm River. A location for this bridge has been identified with rock abutments and a relatively short span, thereby facilitating the placement of girders by crane from the near side, with minimal initial preparation of the far side abutment.

To provide early access to the powerhouse site, a beach head will be established in Devil Cove with the contractor maintaining operation by air or sea. In addition, a marine terminal will be constructed in Devil Cove to facilitate landing of major equipment. This is considered necessary because (existing access road from the Trans Canada Highway to Jackson's Arm) is generally narrow, steeply graded and poorly aligned.

The proposed transmission line will be a single 230 KV line using wood pole construction within a 40 m cleared right-of-way constructed within a 1 km corridor of existing access roads wherever possible. The proposed transmission line routing is illustrated in Figure 4).

As proposed the line will parallel the Cat Arm Development access road from the powerhouse site to the Jackson's arm Highway (Route 77) joining an existing 69 KV transmission line corridor parallel with the Jackson's Arm Highway. The line will divert from the Jackson's Arm Highway and the 69 KV

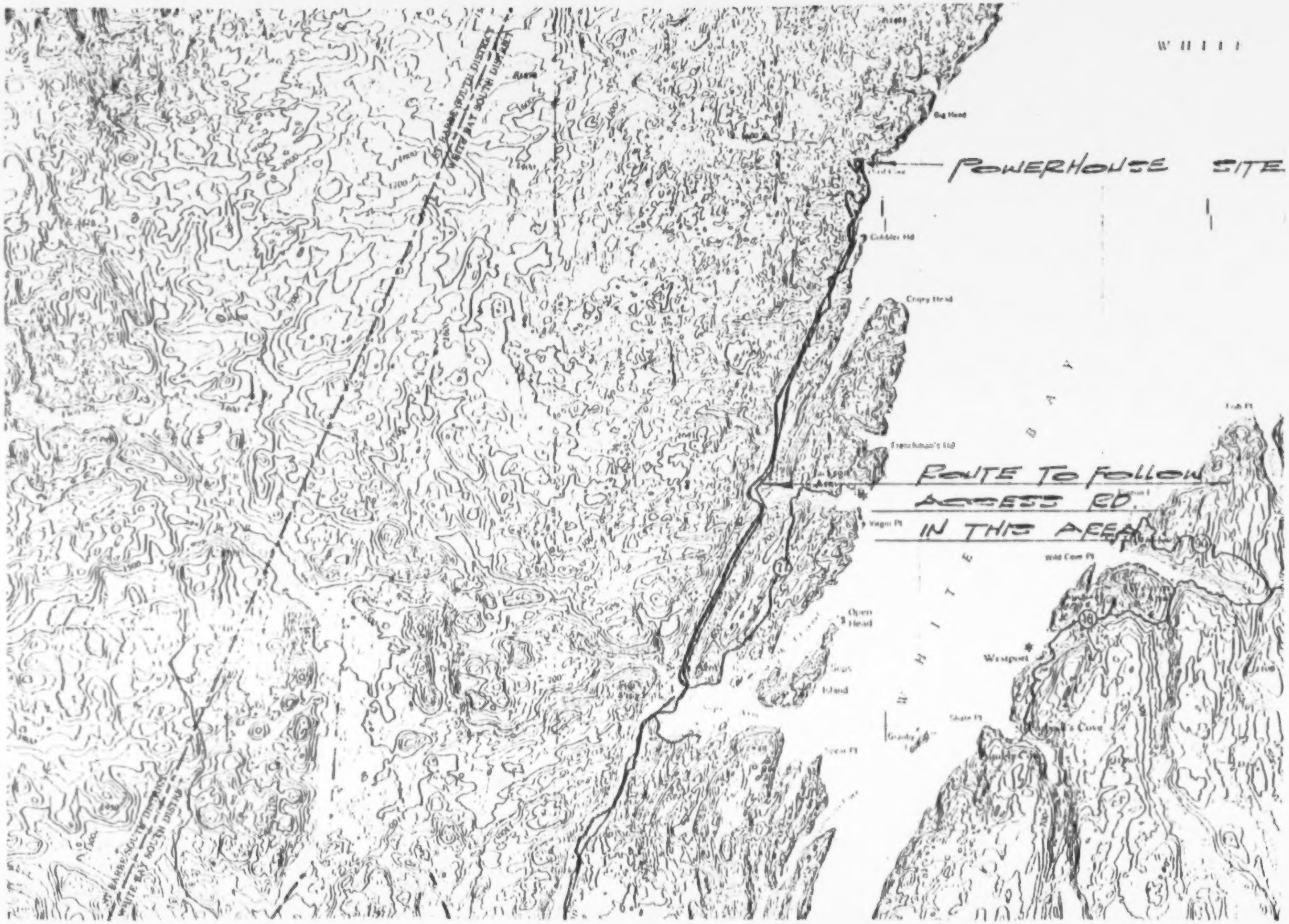

WHITE
BAY
Big Head
POWERHOUSE SITE
Gobbler Hd
Frenchman's Hd
ROUTE TO FOLLOW
ACCESS RD.
IN THIS AREA
Wild Cove Pt
Fish Pt
Open Head
Island
Westport
Shale Pt
Spear Pt
ST. BARBE SOUTH DISTRICT
WHITE BAY SOUTH DISTRICT

Figure 4(a)
Transmission Routing

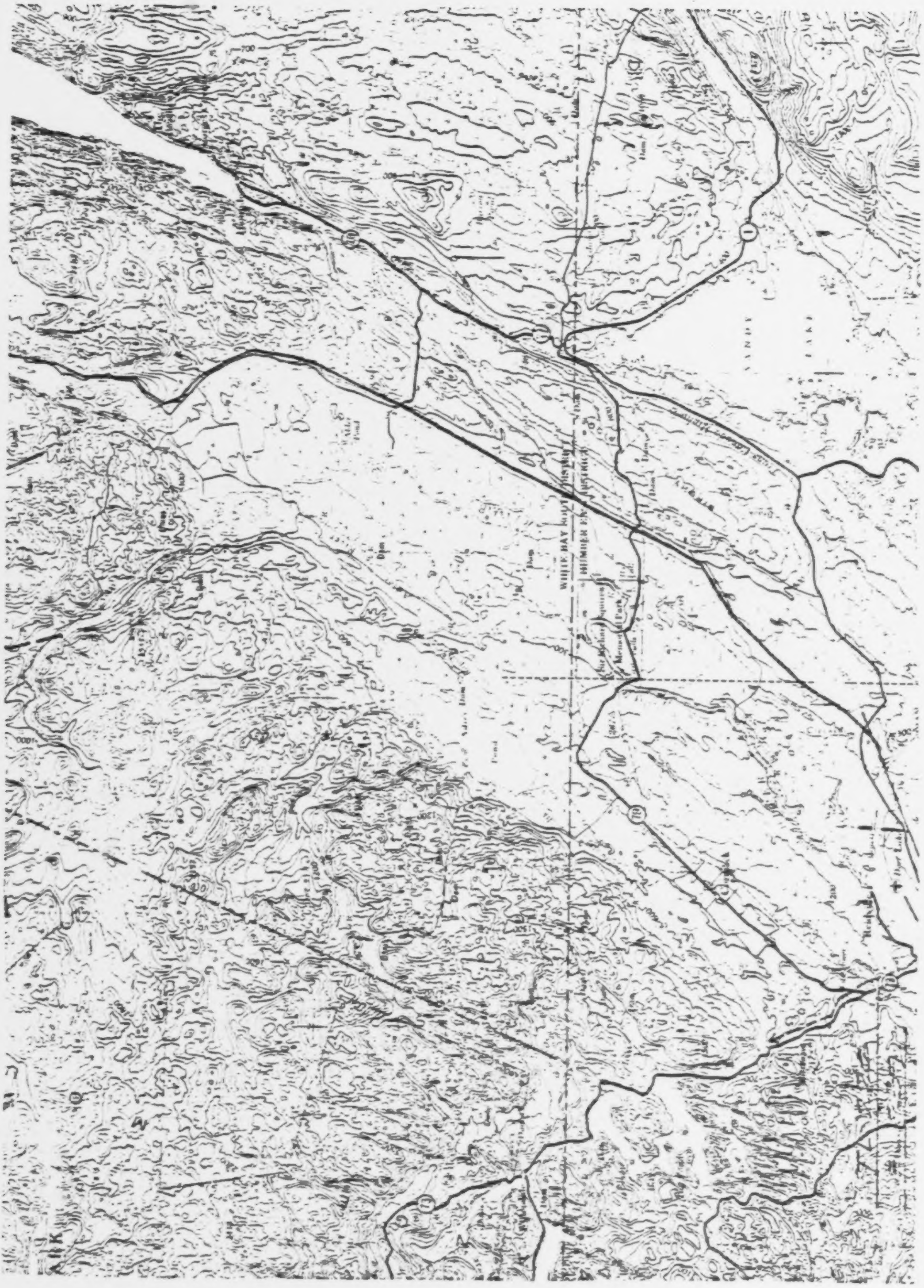

WHITE BAY SOUTH DISTRICT
HUMBER EAST DISTRICT

Figure 4(b)
Transmission Routing

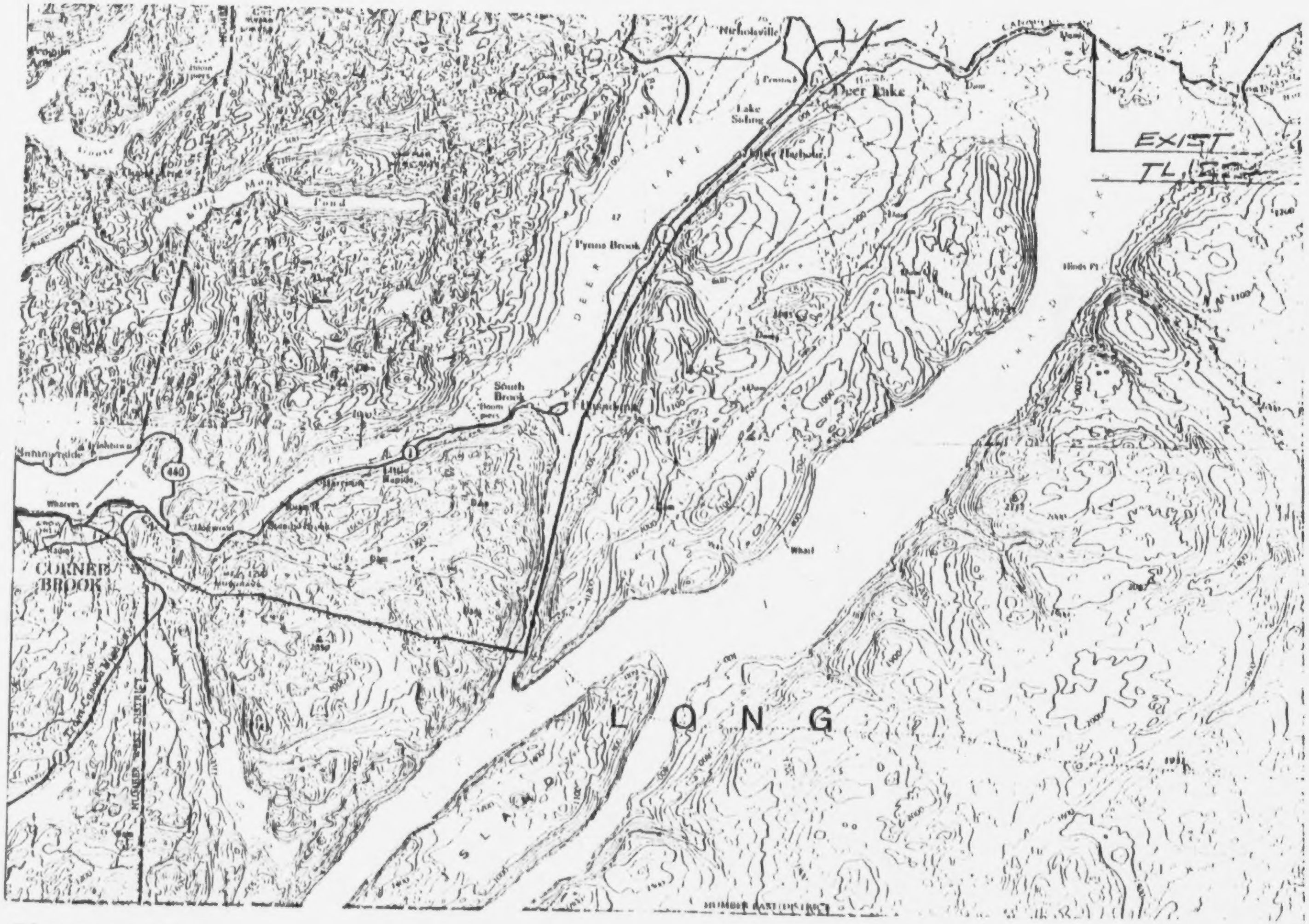

Nicholsville
Deer Lake
Lake Siding
DEER LAKE
Pynns Brook
South Brook
Little Rapids
CORNER BROOK
Hinds Pt
EXIST
TL
LONG
SLAND
HUMBER EAST DISTRICT
HUMBER WEST DISTRICT

Figure 4(c)

Transmission Routing

line corridor at the point where the Highway turns east into the Hampden Highway (Route 76). From this point to the Trans Canada Highway, the line will parallel a series of woods access roads, crossing the Cormack Highway (Route 79) approximately 3.5 km east of the Sir Richard Squires Memorial Park.

At the Trans Canada Highway the line will join an existing 139 KV transmission line corridor parallel with the Trans Canada Highway until it reaches the community of Pasadena. At this point the line will continue in a southerly direction parallel with an existing woods access road until it reaches TL 228 in Northern Harbour on Grand Lake. The line will then parallel TL 228 to the Massey Drive terminal station in Corner Brook. Power will be distributed to the island grid through existing transmission facilities.

2.3 Construction

2.3.1 Schedule

In order to achieve the commissioning dates for the plant and to meet the on-power date of October 31, 1984 it will be necessary to construct the main civil works in accordance with the following schedule:-

- Main access road, March 1981 to June 1982

- Construction camps, June 1981 to May 1982

- Reservoir clearing, April 1982 to December 1983

- Powerhouse, Tailrace and Switchyard, August 1981 to August 1984
- Power and Forebay Tunnels, October 1981 to April 1984
- Forebay Structures and Reservoir Dams, April 1982 to August 1984
- Cat Arm Dam, Spillway and Reservoir Dams, April 1982 to August 1984

2.3.2 Construction Camp

Two main camps with full living facilities will be provided. One will be situated at Devil Cove in the powerhouse area, and the other will be in the vicinity of the Cat Arm Dam.

The camps will consist of: water and sewage treatment plants capable of meeting the demands of a work-force of 700; accommodation in the form of bunkhouse units; kitchen/dining facilities and associated offices; first aid post and warehouse facilities.

Reservoir clearing will probably require mobile camps which would be moved to suit the contractor's requirements.

2.3.3 Borrow Material

Detailed surface and subsurface field investigations were conducted by Shawmont in 1979 (Shawmont, 1980 b). In general, the availability of glacial till overburden in the immediate development area as a source of impervious material for construction of the dam cores is very limited. Field data indicates that an insufficient quantity is available to complete all the dams with a reasonable reserve volume to allow for losses. Some material will have to be hauled from other borrow areas opened during access road construction or from remote borrow areas south of the main development area.

The amounts and types of material estimated to be required for construction of the access roads, both permanent and temporary and the dams are presented below:

Type	Dams	Access Roads
Till	240,000 m^3	115,000 m^3
Sand and Gravel	230,000 m^3	380,000 m^3
Rock	1,500,000 m^3	----

It has been estimated from the subsurface investigation data that a total volume of approximately 200,000 m^3 of impervious glacial till is available in the immediate development area. All of this material is in isolated deposits scattered throughout the northwest area of the Development. It is expected that the remainder of the impervious glacial till required for the Development (approximately 155,000 m^3) will be obtained from borrow areas opened up during access road construction or from along the existing highway between Jackson's Arm and the Hampden Junction.

Rockfill will be obtained by selection from structure excavations and quarries. Filter materials will be obtained from the sand and gravel deposits downstream of the Cat Arm Dam in the Cat Arm River.

Sufficient materials are estimated to be available in the Development area based on the site investigation data.

Coarse aggregates for concrete will be obtained from the sand and gravel deposits downstream of the Cat Arm Dam or by processing quarry rock or beach material in Devil Cove. Sand may have to be transported from outside the development area.

Temporary access roads will be required to borrow areas. Where possible these roads have been located within what will be the future reservoir and as such will be flooded during reservoir filling. It is not possible to indicate at present the actual location and length of temporary access roads required until borrow areas to be used are chosen by contractors.

2.3.4 Manpower Requirements

The estimated number of workers required at the site each month during the construction period is shown on Figure 5. An average of 415 men per month will be required during a 28 month period of a construction schedule of approximately 43 months. The work force will peak at about 600 men for approximately 6 months during the construction period.

CONTRACTOR	1980			1981												1982												1983														
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
RESERVOIR CLEARING																			66	72	72	78	78	78	78	66	66				66	72	72	78	78	78	78	66	66			
CIVIL WORKS							38	42	42	42	42	78	85	105	105	105	105	105	260	384	391	410	475	475	475	402	276	220	220	220	369	390	390	468	455	455	455	385	282			26
TURBINE & GENERATOR																																				23	23	20	20	20	20	20
OTHERS								18	18	23	39	46	61	46	28	30	30	46	48	47	26	31	31	31	31	26	26	33	33	33	33	36	36	31	39	39	39	33	33	26	33	51
TOTAL							38	60	60	65	81	124	146	151	133	135	135	151	374	503	489	519	584	584	584	494	368	253	253	253	468	498	498	577	572	595	595	504	401	46	53	97

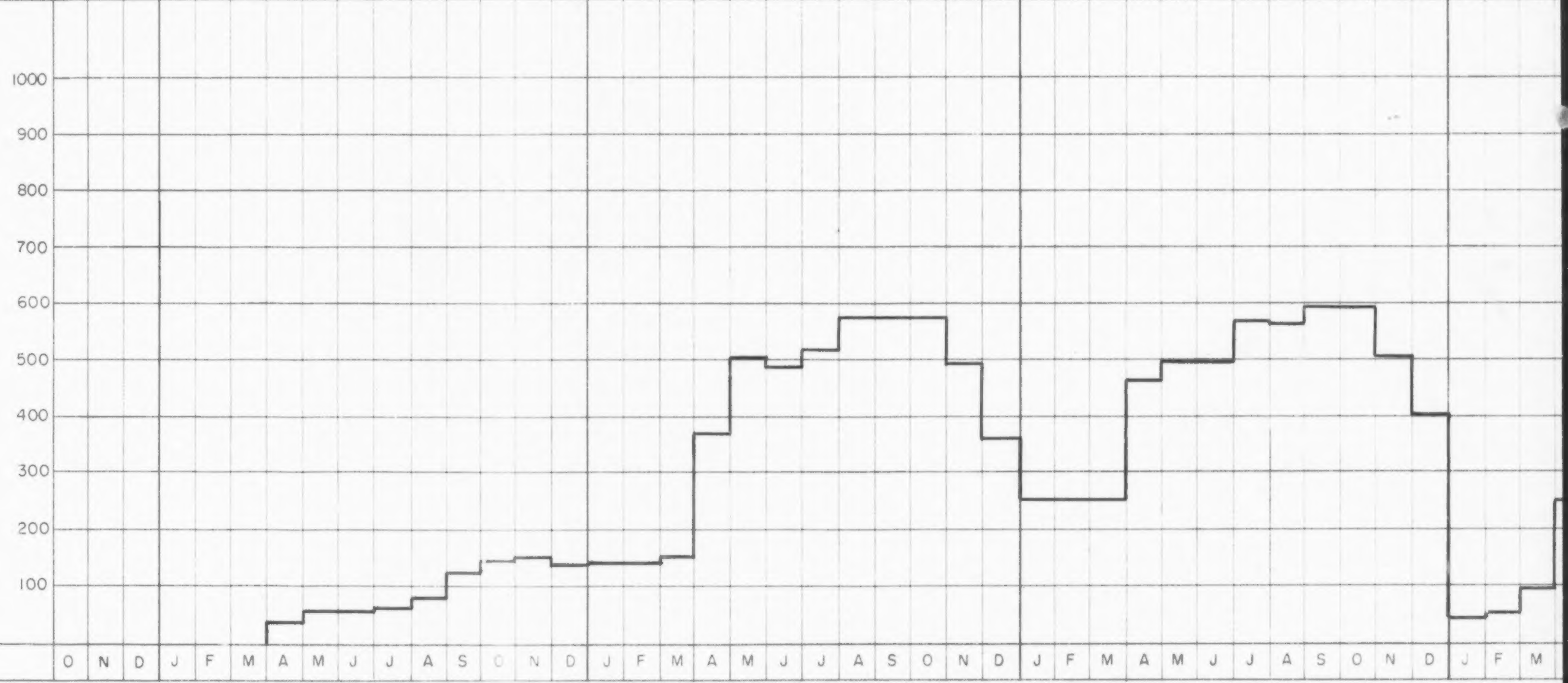
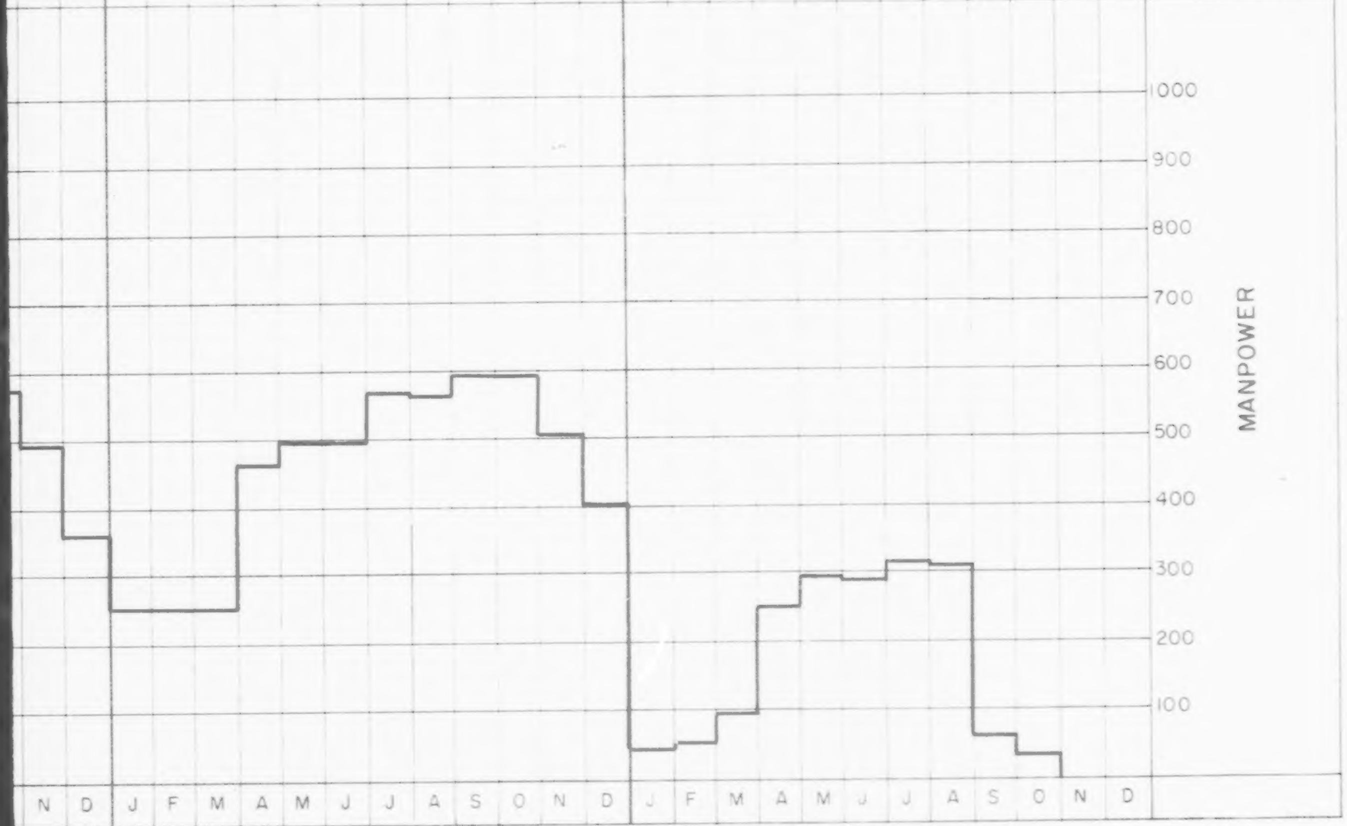


Figure 5

		1983												1984												TOTAL MAN/MONTHS
N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
66	66				66	72	72	78	78	78	76	66	66													1,308
402	276	220	220	220	369	390	390	468	455	455	455	385	282			26	175	215	203	220	220					9,810
										23	23	20	20	20	20	20	20	22	22	23	23	23				279
26	26	33	33	33	33	36	36	31	39	39	39	33	33	26	33	51	51	55	64	69	64	44	39			1,596
494	368	253	253	253	468	498	498	577	572	595	595	504	401	46	53	97	246	292	289	312	307	67	39			12,993



NEWFOUNDLAND & LABRADOR HYDRO

CAT ARM DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

ESTIMATED MANPOWER REQUIREMENTS

DESIGNED	DRAWN S.C.	SCALE	DATE FEBRUARY '80
CONTRACT 1509	FILE No		APPROVED

3. ENVIRONMENTAL SETTING

3.1 Physical Environment

3.1.1 Climate

The Cat Arm River basin is subject to influence from two climatic systems - the continental system over the Canadian mainland and the maritime system over the North Atlantic. This results in a rather unstable climate, characterized by rapid changes in weather conditions. The basin has one of the coolest climates on the Island, together with relatively high precipitation. Because of the mountainous terrain and high relief, weather conditions can vary considerably throughout the area at any particular time.

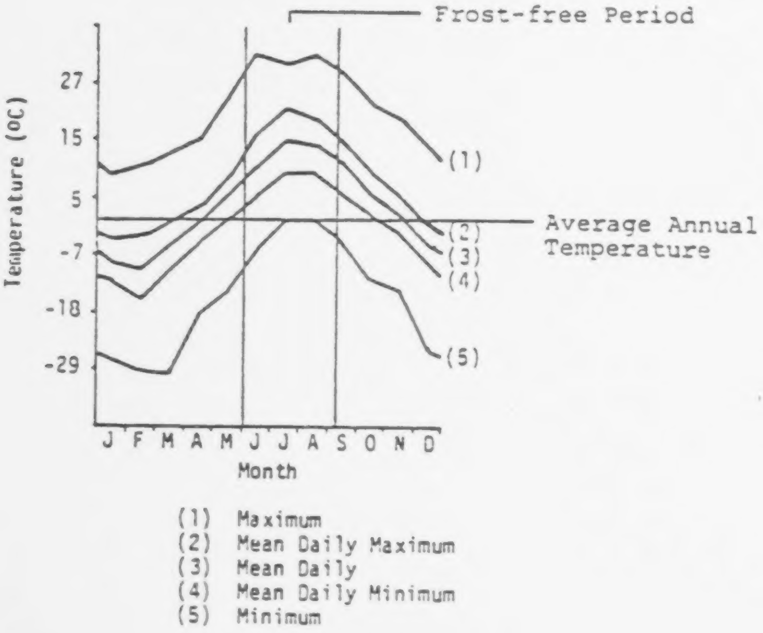
The dominant influences in the climate of the Cat Arm reservoir area are:

- its location on the east side of the Long Range Mountain Plateau with elevations of approximately 400 m above sea level (ASL);
- its proximity to White Bay, which remains free of ice over much of the winter despite the development and flow of pack ice just offshore; and
- the cold Arctic water of the Labrador current that circulates offshore.

The features of the climate in the Cat Arm basin can be interpolated from weather data obtained at stations outside the immediate area (e.g. Daniels Harbour, Baie Verte and Deer Lake).

The temperature graph for Baie Verte is presented as the closest approximation to conditions at the Cat Arm reservoir, due to geographical similarities (Figure 6). Since, Cat Arm is at a higher elevation and is further inland than Baie Verte, it is subject to more continental conditions, and this results in more extreme temperature variations, perhaps as much as 2 C^{o} higher in summer and comparatively colder in winter. The temperature extremes would also be evident on a daily basis, as the exposed bedrock of the reservoir area heats rapidly during sunny days and cools rapidly through cloudless nights. This probably results in a shifting by several days of the beginning and end of the growing season at Cat Arm to earlier in the year than at Baie Verte.

Fig. 6
Temperature, Baie Verte



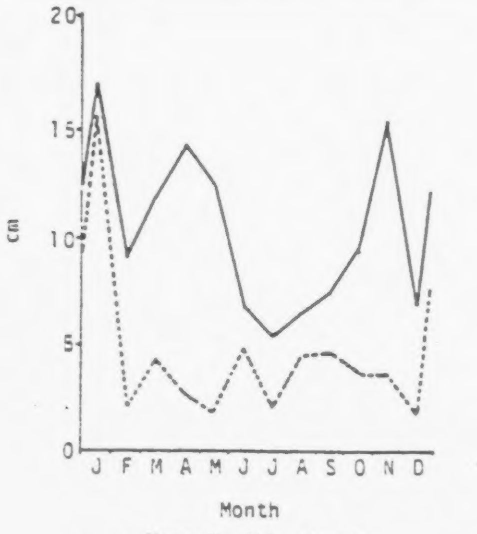
Source: Airphoto/Beak, 1976

Airphoto/Beak (1976) indicate that this growing season lasts from 128 to 140 days, and begins during the last week of May. This is very short, and the Cat Arm area is characterized by cool, short summers and long, cold winters. Dramatic local differences in the growing season occur within the basin due to persistence of deep snow drifts into the summer months on northeasterly slopes.

Precipitation reaches a maximum in winter, falling as snow. A maximum snow depth of 185.4 cm was recorded near the outlet of Cat Arm Lake, although upper portions of the watershed likely receive greater depths. Strong westerly winds also blow snow across the featureless Long Range Plateau adding to the water budget of the upper watershed. Precipitation is lowest in summer, with a minimum of 5.3 cm in July. The mean total precipitation

Fig. 7

Precipitation, Baie Verte



Source: Airphoto/Beak, 1976

from Cat Arm is 122 cm, with the yearly distribution presented in Figure 7. Seasonal peaks occur in November, January and April.

Drought conditions occur infrequently and forests may be fire susceptible when a drought lasts more than 15-20 days. However, there is little evidence of fire history in the region (Airphoto/Beak, 1976).

Sunny days (30% or less cloud cover) show peaks of about 10 days a month in April and May, and then up to about 12 days a month in August. June has a high frequency of fog with little accompanying precipitation, and this results in a dramatic early summer low of about 8 days or 100 hours of sunshine, despite the low precipitation at this time. The cloudiest months occur through the snowy winter.

Strong winds buffet the plateau and induce wind pockets along the rugged coastal cliffs and canyons. These winds generally originate from the southwest or west, but are modified by local topography. Severe wind pruning of shrubs occurs on exposed uplands, while at more sheltered sites downslope trees may grow to 15 m high. Local slope winds and sea breezes are also present. Cold air drainage follows the water drainage contours.

3.1.2 Geology

A. Geomorphology

The Great Cat Arm watershed varies in elevation from sea level to 640 m. It has an easterly aspect and may be broadly subdivided into three topographic units; the high plateau to the west (above 500 m); the 300 m high cliffs and canyon-like fjords and valleys to the east, and the gently rolling dissected uplands that separate them. The entire watershed is characterized by glacially smoothed and scoured bedrock. The hills and valleys are gently rounded, but are generally devoid of overburden, except for bedrock hollows, valley floors and lower slopes, where glacial, alluvial, colluvial and organic deposits have accumulated.

The proposed Cat Arm Development is located on an uplifted fault block forming a plateau with a maximum elevation of approximately 518 m in the vicinity of the Cat Arm Dam site.

A major fault, modified by glacial action and trending parallel to White Bay, defines precipitous sea cliffs along Great Coney Arm and the east side of the Great Northern Peninsula in general. The sea cliffs in the area of Devil Cove rise abruptly to approximately 300 m to a peneplain which is highly dissected, hilly, rugged and barren.

The Cat Arm River, located in this peneplain or plateau of the Long Range Mountains, flows eastward for some 40 km from its source in the highlands to its mouth at Great Cat Arm on the western side of White Bay. The Cat Arm River and its tributaries, west of the Cat Arm Dam site, flow across a more gently rolling terrain compared to the area east toward the coast. At about the Cat Arm Dam site the river takes on a more dynamic character flowing through a steepsided, winding gorge featuring numerous rapids, cascades and one major falls near its mouth. The total drop along the river below the Cat Arm Dam site is 350.5 m with a drop of approximately 23 m at the major falls at the river mouth.

The typical landforms on the plateau are barren hills and ridges, and glacier carved valleys spotted with many linear shaped ponds. Numerous bedrock outcrop, marshes and tuckamore areas exist. Morainal landforms appear lacking throughout the region.

B. Bedrock Geology

Geological field investigations were carried out at the site of the Cat Arm Development during 1977 and 1979 by Shawmont Newfoundland Limited as part of the engineering feasibility (Shawmont, 1980 a). Earlier investigations, (British Newfoundland Exploration Company, 1954, Baird, 1959, and Neale and Nash, 1963 provided background information for the most recent field investigations.

The bedrock of the Cat Arm watershed is part of the Grenville Province of the Canadian Shield, which was deformed and metamorphosed about 980 million years ago. This rock was subsequently overlain by lower Paleozoic sedimentary rocks which were later removed by erosion following uplift and intrusion into the Grenville rocks of diabase dyke swams some 640 million years ago. Most of the bedrock of the watershed is silicic biotite schists and gneisses which were at least in part derived from sedimentary rocks. In the west part of the area, younger metamorphosed intrusive rocks predominate, and include some metagabbro (Airphoto Analysis/Beak, 1976).
The predominant foliation in the area trends somewhat NE/SW and the dykes, generally paralleling the foliation, dip steeply NW.

Faulting is apparent in the area between the proposed Forebay Canal and Devil Cove. A long, prominent and very wide fault zone, trending along the west coast of White Bay has disrupted the rock formation on the east side of Devil Cove. Crustal movement in this area does not appear to have affected the rock underlying the proposed powerhouse site since diamond drill core from the site displays continuous rock formation without faults. Inland from Devil Cove a number of east/west and north/south trending faults underlie some of the proposed Development structures. Information from diamond drill core, field observations and water pressure testing indicates that these fault zones should not present any unique foundation or tunnelling problems. (Shawmont, 1980 b).

The Cat Arm Development area is situated in a region of very low seismic intensity (Personal Communication, I.C. Stewart, Seismologist, MUN). The only recorded earthquakes in several decades of recording occurred about 10-15 years ago along the Cabot Fault System which trends from near Port aux Basque north along the eastern side of the Great Northern Peninsula. These earthquakes were of low magnitude with epicenters near Deer Lake and Hampden. On the basis of present seismic data and the inactive state of faults in the Cat Arm area, the likelihood of significant future seismic activity is remote and provides no significant threat to the Cat Arm Development (Shawmont, 1980 a).

C. Surficial Geology

A biophysical land classification of the proposed Development area was conducted by Airphoto/Beak (1976) and further elaborated by Slaney (1978), Hunter (1980) and Shawmont (1980 b).

These studies obtained information on the physiography, surficial deposits, soils and vegetation of the Development area in order to differentiate and classify ecologically significant elements of the land surface. The Cat Arm Biophysical Study (Slaney, 1978) shows a detailed delineation of the surficial geology as it relates to landform, vegetative cover and wildlife habitat. The following summarizes the findings of the surficial geology evaluations.

The Cat Arm watershed consists of a high easterly sloping plateau penetrated by canyon-like fjords and terminating in 300 m high cliffs along the fjord and sea cliff margins on the east. The proposed Development area is "nestled" on this gently rolling upland plateau just above the westerly limit of Great Cat Arm fjord.

The proposed Development area lies at the former confluence of glacial ice streams that entered the Great Cat Arm Fjord. As a result, the bedrock terrain is scoured and rounded and overburden is thin. On glacial retreat, ablation moraines were formed and large melt-water flows from the westerly plateau discharged through the reservoir valleys eroding the glacial drift leaving behind large boulder erratics. Overburden (glacial drift) is restricted in occurrence to the valley floors and lower slopes in the northwestern part of the reservoir. Till deposits are relatively small and widely scattered. The overburden consists of a bouldery glacial till with a matrix of silty sand and gravel. Large angular surface boulders up to 6 m in diameter are common in the area. This glacial till matrix has been modified to some extent by meltwater action. Generally the overburden is 1 to 3 m in thickness, however small deposits up to 8 m thick do occur in the river valley upstream from the dam. Good tree growth results on this overburden. Scattered erratics and sub-angular boulders and washed bedrock occur throughout the upland portions of the reservoir, especially in the south. Tree growth is poor or non-existent in these areas.

Postglacial fluvial erosion in the Cat Arm River has cut down the outlet of Cat Arm Lake resulting in wave-washed bedrock lake margins and extended coarse textured deltas in the inlet streams, however sediment transport of the inlet streams is low and delta formation is a very slow process.

Organic accumulation occurs on wet slopes where groundwater discharges from the shallow drift, and on mild slopes and in depressions throughout the reservoir area.

D. Mineral Potential

There is currently no mineral development in the Cat Arm Project area. The entire area affected is still unlicensed Crown Land.

The Project area was included in an aeromagnetic survey (Geological Survey of Canada, 1968), and the northernmost part of the area was covered by part of an aeroradiometric survey flown by Leich Gold Mines Limited (D'Aiges, 1968). No significant anomalies were discovered in either survey. In 1975 the Geological Survey of Canada reported the presence of a uranium anomaly southwest of the Cat Arm watershed over intrusive granite of the Long Range Complex north of Portland Creek-Inner Pond. More recently, in 1978 and 1979, Cominco Limited carried out a reconnaissance program for uranium mineralization in an area to the north of the Cat Arm watershed. The survey detected areas of low intensity radiometric anomalies throughout the area, however, the results of groun prospecting, mapping and geochemical lake sediment, and soil sampling have not yet been made public. The Cominco claim block 1341, Lic. No. 1173 and claim block 1104 Lic. No. 1129 represent the only mineral land holdings in the area that are close to the watershed and in an apparently similar geological environment (pers. comm. B. Greene, Department Mines and Energy, 1980).

Because of the lack of geological mapping and prospecting in the Cat Arm River watershed area, its mineral potential can only be speculated. However, the discovery of radioactive anomalies by Geological Survey of Canada (1975) and Cominco in 1978, in rocks of a similar geological environment suggest that uranium mineralization of economic interest may be present. Such discoveries are not new for the Grenvelle, a province in which the first discoveries of uranium in Canada were made years ago (Lang, 1961). Uranium minerals associated with pegmatite-granite-metamorphic environments in the Grenville have been successfully exploited by mines in the Bancroft, Ontario area and several prospects are located along the north shore of the Gulf of St. Lawrence including significant uranium deposits at Bare Johan Beetz, Quebec (Hauseax, 1977).

3.1.3 Hydrology

The proposed Cat Arm Development will utilize water from three drainage basins: the Cat Arm River above the proposed Main Dam (632.5 km^2) which presently flows into Great Cat Arm, the eastern diversion (9.6 km^2) and head pond (8.6 km^2) areas which are presently drained by small unnamed rivers flowing eastwards into White Bay (Figure 3).

Natural water surface elevations in the main drainage area vary between a minimum of about 350.5 m above mean sea level (AMSL) at the Main Dam site to a maximum of about 594.4 m in the headwaters of the Cat Arm River near the western boundary of the drainage area. A considerable portion of the total area is, however, relatively flat with many small lakes and bogs. Natural water surface elevation in the head pond is approximately 382.5 m (Shawmont, 1977).

The hydrology of the area is described in detail by Airphoto/Beak (1976). The high western portion of the drainage basin is alpine plateau and is terminated by steep easterly and northeasterly slopes with a scrub forest, fen and zabois.
Snow melt is delayed late into summer.
The patterned fens are saturated for much of the year and are quickly recharged by snow melt and autumn rains. They provide a steady supply of water to the major tributary streams arising on the north-western and south-western half of the plateau. The easterly portion of the watershed

is rock upland, and runoff is rapid; because small ponds, rocky depressions and isolated fen provide only limited water storage capacity. This half of the basin contains the majority of the present pond system and will contain the future reservoir. The ponds are really widenings in the Cat Arm River and flooding of 1-2 m occurs after spring snow melt.

The hydrographs of the Cat Arm River, installed in October, 1968 at the proposed Main Dam site, exhibits characteristics and fluctuations typical of an unregulated, upland water course in Newfoundland. Minimum flows (less than 3 m^3/s) occur in winter as a result of accumulation of snow on the ground and obstruction of lake outlets by ice.

Climatic conditions in the Cat Arm area result in snow melt accounting for a large percentage of the total annual runoff. The peak runoff (280 m^3/s) occurs during spring snow melt in April and May. Between mid June and the end of November these broad scale fluctuations are replaced by high amplitude, short wavelength cyclical response to alternating summer storms and temporary deletions of upstream surface and ground water storage. The extreme variations, 1-100 m^3/s within two week periods, are directly related to the large area of bedrock surface and the low storage capacity of the shallow coarse textured overburden and organic terrain that occurs throughout the watershed.

The mean discharge of the upper system at the main dam site is 26.3 m^3/s and the yield of the drainage basin is 0.0416 $m^3/s/km^2$. The drainage basin of the plateau above the reservoir zone (above 396 m) is estimated to be 570 km^2 and the mean flow from this total area is 23.7 m^3/s. The drainage basin below the dam site on the Cat Arm River is estimated to add an additional 148 km^2 to the total drainage basin of the Cat Arm River. Using the yield factor calculated for the plateau, the mean discharge at the Great Cat Arm is estimated to be 32.5 m^3/s (Beak, 1980).

The relatively high average unit runoff from the Cat Arm drainage area is a result of high annual precipitation, low evapotranspiration and low infiltration. The storage capacity of the present small lakes is low, with an estimated residence time of 2 to 3 days (Beak, 1980).

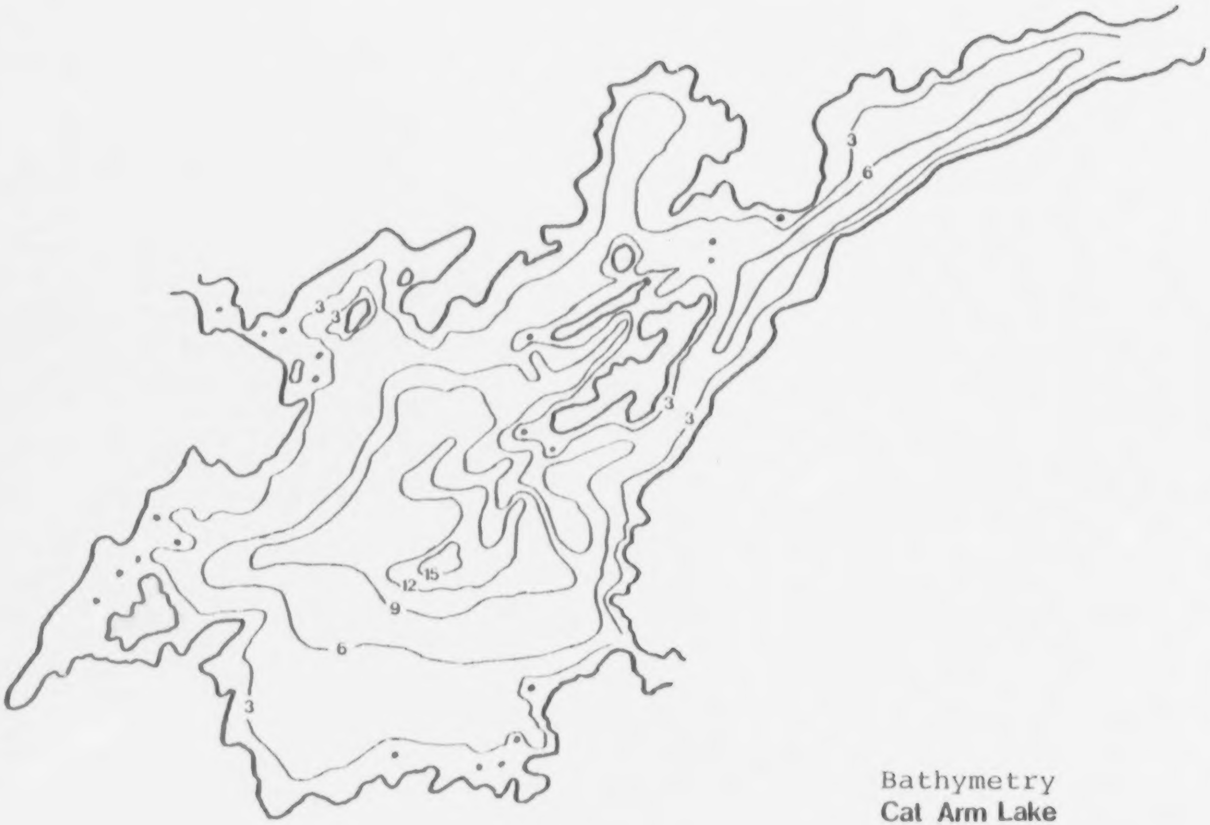
A frequency analysis of the Cat Arm recorded peak flows indicates that the 20 - year spring and fall flows are about 493 m^3/s and 214 m^3/s respectively. Daily discharges of 280 m^3/s have been recorded.

3.1.4 Morphometry of Lakes and Ponds

The morphometry of the present lakes and the relationship of morphometry to the physical and biolimnological features of the lakes was investigated by Airphoto/Beak (1976) and Beak (1980).

The lake which forms the major water body in the potential Cat Arm development area is located at the head of the Cat Arm River, 18 km upstream from the estruary at an elevation of 360 m.

Figure 8


3
6
3
3
3
3
15
12
9
6
3

Bathymetry
Cat Arm Lake

depth in metres

SOURCE: Beak, 1980

A series of much smaller lakes and ponds are found within the watershed and empty into Cat Arm Lake through a series of small creeks and overflows between pond basins.

Cat Arm Lake has the largest single basin in the plateau lake system. It receives both the north and south branches of the Cat Arm River. Beak (1980) found the lake to be quite shallow (mean depth 5 m, maximum depth 15m) with an extensive shallow littoral zone and many islands (Figure 8). The lake bottom is primarily bedrock or boulder with many exposed and submerged shoals. Thick layers of fine grained sediments are not abundant. The occurrence of exposed and submerged rock shoals were also observed in the other lakes and ponds of the system.

The volume of the Cat Arm Lake is estimated to be 5.5 million m^3 with an average flushing rate of 2.4 days. At peak flow, turnover times are only a few hours. No thermal stratification occurs in the lake and oxygen levels are near saturation throughout the water column. Fine organic and inorganic sediments which may settle during quiescent periods are scoured away during flood periods. The flushing rates of the other lakes will also be high although they will handle less than one-half the discharge that Cat Arm Lake receives.

3.1.5 Marine Morphometry, Shoreline Type and Sediments

The morphometry, shoreline type and bottom sediments of the Great Cat Arm and Devil Cove were investigated by MacLaren Atlantic Ltd. (1978).

Great Cat Arm

Great Cat Arm is a glacial fjord, 9 km in length, 1 km in average width, and with a maximum depth of 84 m. It has a sill at 46 m depth near the mouth. Maximum depths occur just inside the sill and decrease gradually towards the head. Cross sectional bottom profiles are V-shaped. The Cat Arm River enters at the head of the Arm from a rocky delta and is the only significant single source of freshwater in the Arm. Great Cat Arm is bordered by abrupt rock faces and slopes (300 m in height).

Three shoreline types occur within Great Cat Arm: exposed bedrock as cliffs and protrusions into the Arm; cobble composed of coarse boulders lining the shore; and gravel and sand beaches. The first is the most common shore type overall, but gravel beach dominates near the head of the fjord.

Sediments near the head of Great Cat Arm (Figure 9) are mainly organic particulates, small pieces of bark and other plant detritus derived from the Cat Arm River. The more seaward parts of the fjord have fine black ooze in mid-fjord and ooze mixed with stones at shallower stations. Substrate on the edge of the fjord sill is a fine silty sand with small rocks lying loose on the surface.

Devil Cove

Devil Cove is a 500 m diameter U-shaped indentation in the coastline surrounded by high rocky headlands. The central part of the Cove is a shallow basin (25 m maximum depth) bordered seaward by a sill (17 m depth). The bottom of the Cove is smooth and U-shaped (Figure **10**).

The shoreline at Devil Cove consists of rock outcrops and cliffs at the headlands. Most of the shoreline in the Cove is made up of boulders with a fine beach occurring at the head of the Cove near a small freshwater stream.

Sediment in the central part of the Cove and on the sill is a fine silty sand. Approaching the headlands, the substrate becomes rocky. A subtidal boulder field fringes the central part of the Cove just within the headlands. The boulder size decreases along the approach from the headlands to the tidal line at the head of the Cove.

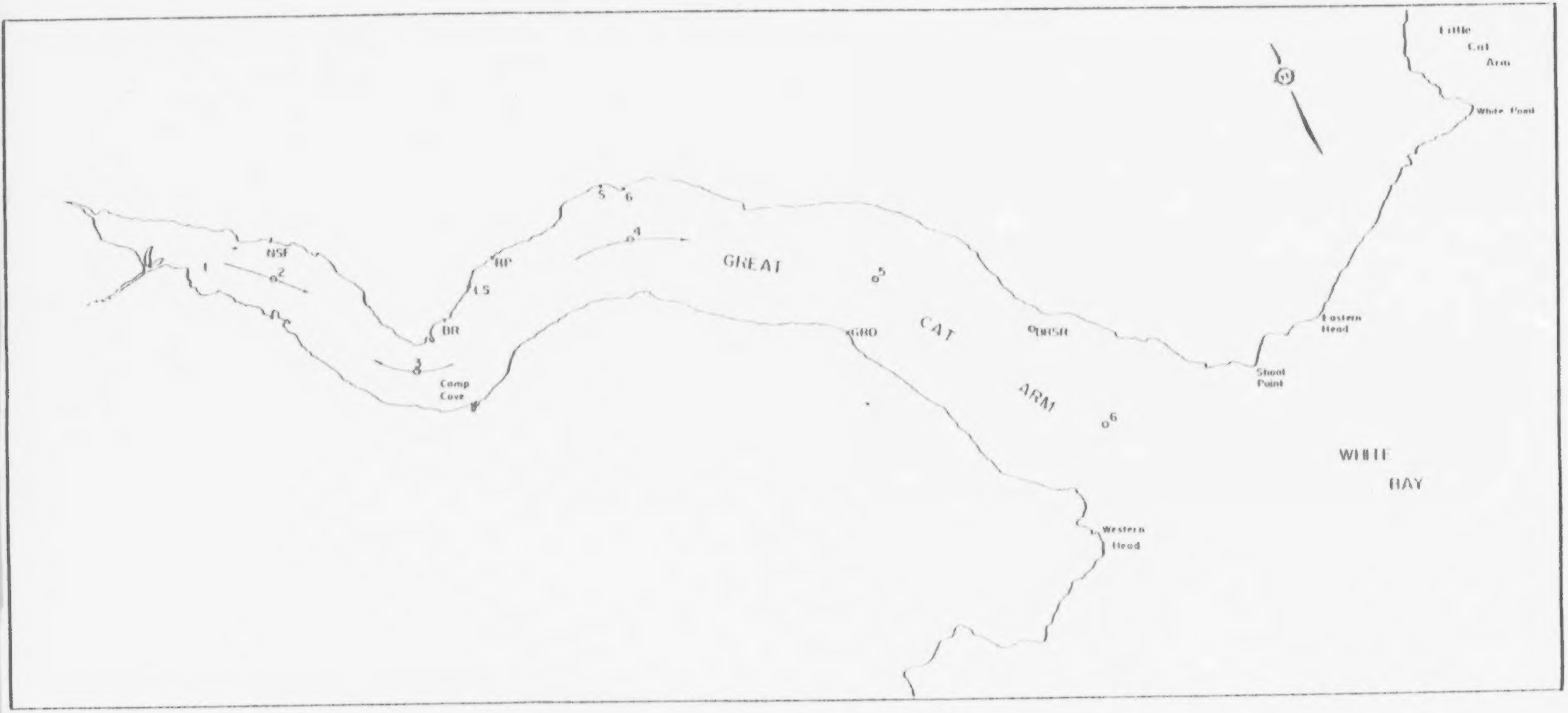
3.1.6 Water Quality

Water quality samples were taken from a number of lakes and streams throughout the total drainage basins (Airphoto/Beak, 1976; Beak, 1980). The sampling program was designed to provide a basis for future water quality monitoring.

The surface water chemistry of any given region is controlled by rainfall composition, vegetation and soil types, and bedrock and till aquifer composition. On the upper plateau, where the Cat Arm

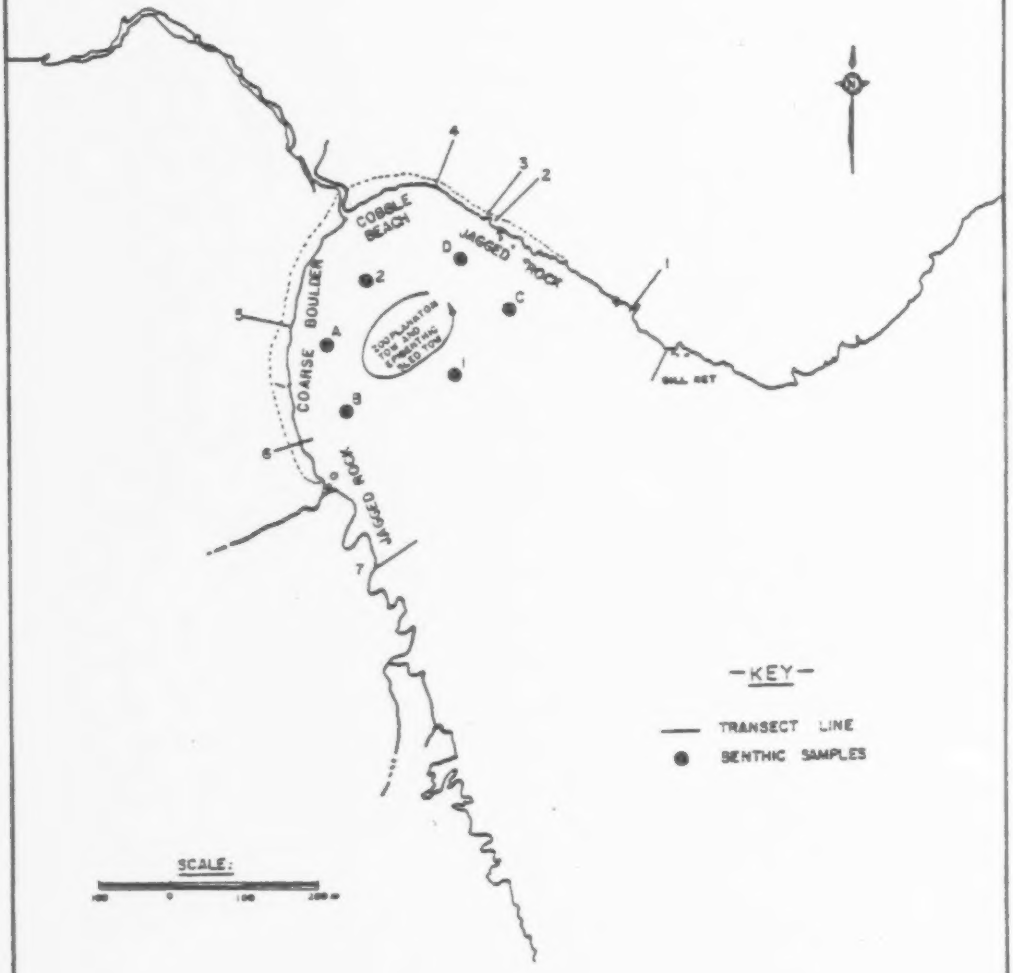
Figure 9

The Great Cat Arm


Little
Cat
Arm
White Point
Eastern
Head
Shoot
Point
WHITE
BAY
Western
Head
GREAT
CAT
ARM
NSF
RP
LS
BR
Camp
Cove
GRO
NNSR
1
2
3
4
5
6
5
6

SOURCE: MacLaren Atlantic, 1977

Figure 10


N
4
3
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1
5
6
7
COBBLE BEACH
JAGGED ROCK
COARSE BOULDER
JAGGED ROCK
ZOOPLANKTON TOW AND EPIBENTHIC SLED TOW
D
2
C
A
1
B
GILL NET
-KEY-
TRANSECT LINE
BENTHIC SAMPLES
SCALE:
100
0
100
200 m

LOCATION OF INTERTIDAL - SUBTIDAL TRANSECTS AND BENTHIC SAMPLES, DEVIL COVE, NEWFOUNDLAND

MacLaren Atlantic, 1977

drainage system originates, the bedrock is composed mainly of granite gneiss overlain by a thin veneer of glacial till. The vegetation is primarily fir forest and heath.

The rapid hydrographic response found in the Cat Arm system indicates a rapid surface runoff which leaches the thin soil horizon, but does not pick up much in the way of dissolved inorganic ions from parent material. Consequently, the waters of this area are very soft, with an average conductivity of about 22 mhos/cm^2 and an average hardness in August of only 4 mg/l and in late September of 12 mg/l. Average colour values are between 90 and 200 Co/ft units, making this one of the most highly coloured in the province. Much of this colour is probably due to the presence of organic acids. The relatively high acidity of 15 mg/l is probably due to organic acids and the highly aerated nature of this water. Values for pH are extremely low (4.6), and may be a limiting factor in success of brook trout egg hatchability and growth. Sodium and chloride are the two most dominant cations and anions in the area, indicating that much of the ionic material is derived from precipitation originating over the ocean. Other cations are present at very low levels (Table 1).

An analysis of the soluble and particulate fractions indicates that certain ions such as manganese, magnesium, and iron are tied up in the particulate phase and indications are from theoretical solubility data that a much larger fraction is tied up in the colloidal phase. The mechanism for this is probably the formation

Table 1

Water Chemistry in Cat Arm Watershed

	South Inlet	Seepage	Outlet
Alkalinity mg/l	1.0	-	0.6
Hardness mg/l	-	-	4.2
pH	5.42	4.28	5.03
Conductance u mhos/cm.	16.76	34.78	19.37
Chlorphyl-a mg/l	<0.01	<0.01	N.A.
Acidity mg/l	-	15	-
Chloride mg/l	3.9		
Sulphate	3.0		
Total Kjeldahl N mg/l	0.231	0.394	0.394
% Soluble Kjeldahl N	40	57	63
% Particulate Kjeldahl N	60	43	37
Nitrate mg/l	<0.01	<0.01	0.012
Chemical Oxygen Demand (as carbon) mg/l	35.5	92.5	41.8
% Soluble COD	53	77	77
% Particulate COD	47	23	23
Phosphorous mg/l	0.056	0.073	0.040
% Soluble P	38	75	63
% Particulate P	62	25	37
Silicate mg/l	0.073	0.436	0.143
Total Calcium mg/l	0.535	1.270	0.745
% Soluble Calcium	100	92	94
% Particulate Calcium	0	8	6
Total Magnesium mg/l	0.261	0.682	0.408
% Soluble Magnesium	61	97	67
% Particulate Magnesium	39	3	33
Total Manganese mg/l	0.017	0.033	0.017
% Soluble Manganese	59	85	58
% Particulate Manganese	41	15	42
Total Iron mg/l	0.386	1.018	0.498
% Soluble Iron	30	88	48
% Particulate Iron	70	12	52
Total Zinc mg/l	<0.01	<0.01	<0.01
Total Molybdenum	<0.001	0.003	<0.001
Total Cobalt mg/l	<0.01	<0.01	<0.01
Total Sodium mg/l	1.303	2.352	1.725
Total Potassium mg/l	0.230	0.230	0.200
Floride mg/l			0.1
Copper mg/l			.004
Zinc mg/l			<.01
Cadmium mg/l			<0.01

Source: Airphoto Beak, 1976, Beak, 1930

of metallo-organic complexes with humic and fulvic acids in the soils which are leached into the ponds and rivers in the area. The fact that most of these metals, which are very scarse, are tied up in colloidal and soluble complexes, is very important from a productivity stand point. These metals are, in all probability, limiting productivity because they are physiologically unavailable until the complexes binding them are broken down, freeing both trace metals and organic carbon. This probably happens to a small extent in the lake itself through bacterial and ultraviolet oxidation, but to a much larger extent in the river and estuary.

Other nutrients are generally quite scarce. Nitrate levels are very low, (in most cases less than 0.1 mg/l) and are probably limiting in these waters. The levels of both total and ortho-phosphate in these waters are high in relation to nitrogen, but on an absolute scale are considered low for natural waters. The largest amount of nitrogen in these waters is tied up as organic nitrogen, probably as soluble and colloidal humic materials. The most abundant nutrient in the system is carbon, but for the most part it appears to be tied up in humic material and of limited availability. The overall carbon:nitrogen:phosphorus ratio appears to be about 100:1:1, but this is probably not an indication of available ratios. Nevertheless, it points to the fact that available nutrients in the system are severly limiting its oxidation. Silica appears to be at levels which would be limiting to diatom populations in lakes.

3.1.7 Physical Oceanography

Measurement of physical oceanographic features of the Great Cat Arm and Devil Cove was completed by MacLaren Atlantic Ltd (1978) as part of a marine ecology study. Field samples were collected in June, September and October, 1977 througout Great Cat Arm, in White Bay at the mouth of Great Cat Arm, and in Devil Cove (Figures 9 and 10).

Great Cat Arm

Great Cat Arm is a fjordic estuary, a system with a fresh or slightly saline surface layer and a deeper sea-water layer which extends to the head of the estuary. In June, 1977, the lower salinity surface layer (5^{o}/oo) was a maximum of 2 m thick at the head of the estuary (Figure 10) decreasing to a depth of less than 1 m and a salinity of less than 10^{o}/oo near White Bay. The river flows were quite large through the observation period, having peaked on 5 - 6 June (Table 2). A salt balance calculation made at the mouth of Great Cat Arm at this time showed the inflow of salt-water in the bottom layers to be 0.4 times the volume of river flow. This is typical of a fjordic situation where tidal and wind mixing is minimal and river flow is the main factor governing mixing.

The maximum velocity of the outflowing surface current was 0.7 m/s with velocities decreasing with increased depth in the surface layer down to the main pycnocline (fresh-water-saltwater density interface). The freshwater layer was deeper towards the middle of the Arm. Higher surface salinities were observed adjacent to the shoreline as a result of shoreline turbulence.

The situation was similar in September, but in this case, the river flow was lower (Table 2) and the weather stormy, thus decreasing the dominance of river flow in mixing. A low salinity (5^{o}/oo) layer 2 m thick was observed at the head of the estuary. This layer decreased in thickness to 1.5 m at Station 2 and further with distance down the estuary (Figure 11). Probably as a result of the

Table 2

FLOW MEASUREMENTS OF GREAT CAT ARM AND DEVIL COVE WATERSHEDS

Date	Cat Arm River Flow (m^3/s) At Reservoir	Total	Estimated After Diversion	Flow into Great Cat Arm (m^3/s) Total	Estimated After Diversion	Estimated Flo into **Devil Cove** (m^3/s)
Average Flow[1]						
January	8.0	9.9	1.9	11.1	3.2	0.3
February	5.9	7.3	1.4	8.3	2.4	0.2
March	6.6	8.2	1.6	9.3	2.6	0.2
April	19.2	23.8	4.6	26.8	7.6	0.8
May	78.0	96.7	18.7	109.0	31.0	2.5
June	67.8	84.0	16.2	94.6	26.8	2.2
July	15.2	18.8	3.6	21.2	6.0	0.5
August	16.4	20.3	3.9	22.9	6.5	0.5
September	13.8	17.1	3.3	19.3	5.5	0.4
October	21.8	27.0	5.2	30.4	8.6	0.7
November	27.0	33.4	6.4	37.6	10.7	0.9
December	16.1	20.0	3.9	22.5	6.4	0.5
Discharge Extremes[2]						
Maximum recorded	373.8	463.1	-	521.8	-	12.0
Minimum recorded	0.4	0.5	-	0.6	-	0
Flow During[3] Sampling Periods						
June 5	339.8	420.9		474.3		10.9
6	345.5	428.0		482.2		11.1
7	242.1	300.0		338.1		7.8
8	194.3	240.7		271.2		6.3
9	210.4	260.7		293.8		6.8
10	242.1	300.0		338.1		7.3
11	236.2	292.6		329.8		7.6
12	222.3	275.4		310.4		7.2
September 26	15.7	19.5		21.9		0.5
27	13.9	17.2		19.4		0.4
28	25.7	31.9		35.9		0.8
29	54.1	67.0		75.5		1.7
30	54.1	67.0		75.5		1.7
October 1	48.7	60.3		68.0		1.6
2	46.7	57.9		65.2		1.5

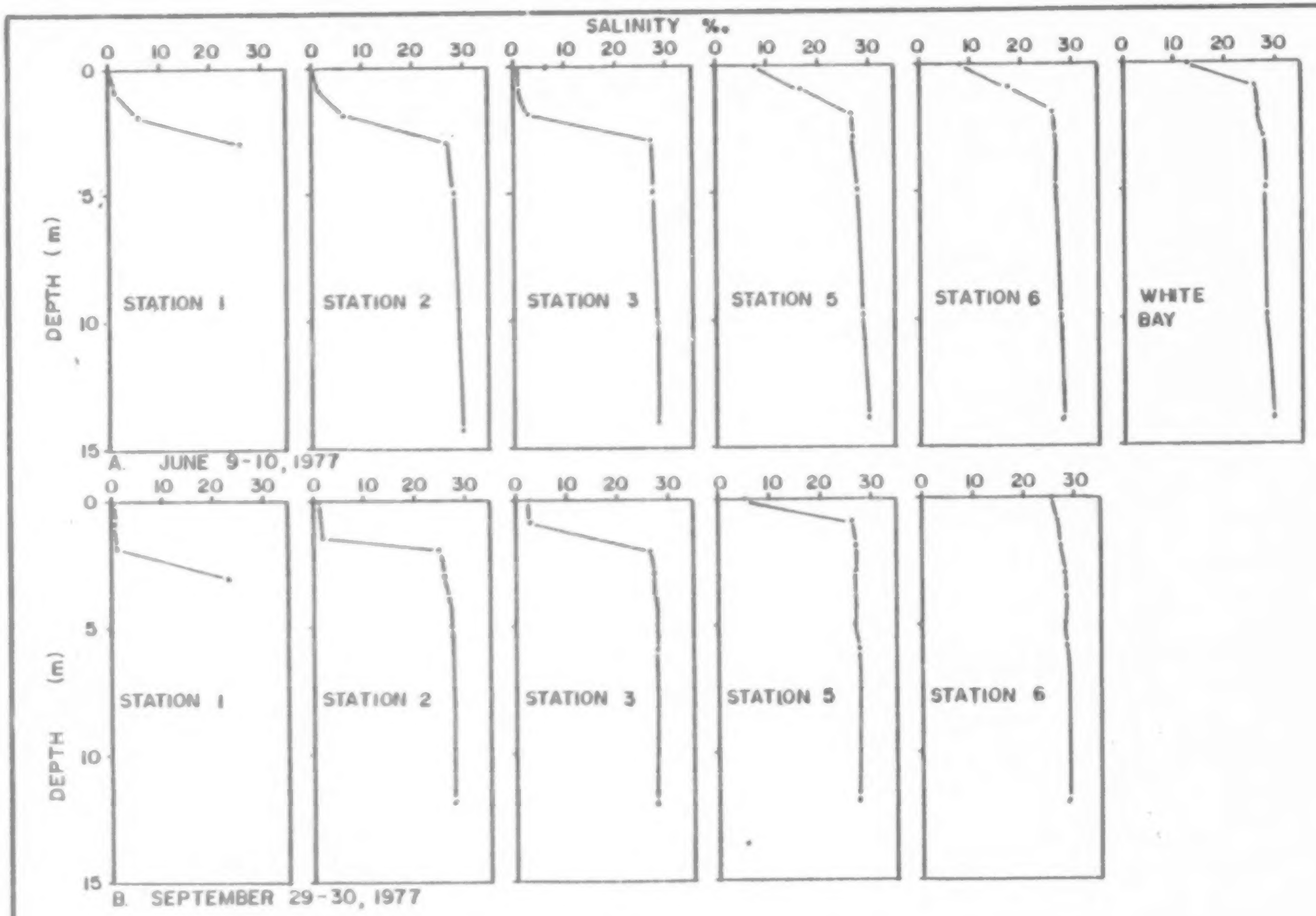
[1] Based on Shawmont Newfoundland, 1977, and drainage area ratios from Airphoto-Beak, 1976.

[2] Airphoto-Beak, 1976

[3] Environment Canada; Dr. W. Ullah; and drainage area ratios

SOURCE: MacLaren Atlantic Ltd., 1977

Figure 11



LONGITUDINAL PROFILE OF SALINITIES IN GREAT CAT ARM, NEWFOUNDLAND

SOURCE: MacLaren Atlantic, 1977

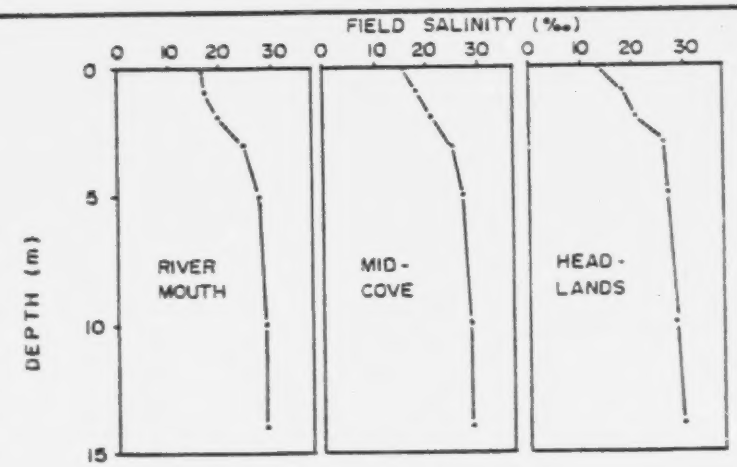
storm conditions and the resultant forcing of surface freshwater into the estuary head, the low salinity layer had largely disappeared at Station 6.

Circulation and salinity distribution in Great Cat Arm is dominated by river inflow with tidal and wind induced mixing playing a minor role. Seasonal reductions in freshwater inflow likely result in a reduction in extent and thickness of the freshwater layer. Thus a highly stratified freshwater/saltwater regime likely exists at least in the landward third for the major part of the year. During extremely low flows in summer and winter (Table 2), the thickness of the layer is probably reduced to 0.5 to 1 m rather than 1 to 2 m found during the surveys. The low salinity surface layer (5^{o}/oo) probably does not penetrate beyond the first bend under these low flow conditions, except perhaps under ice cover.

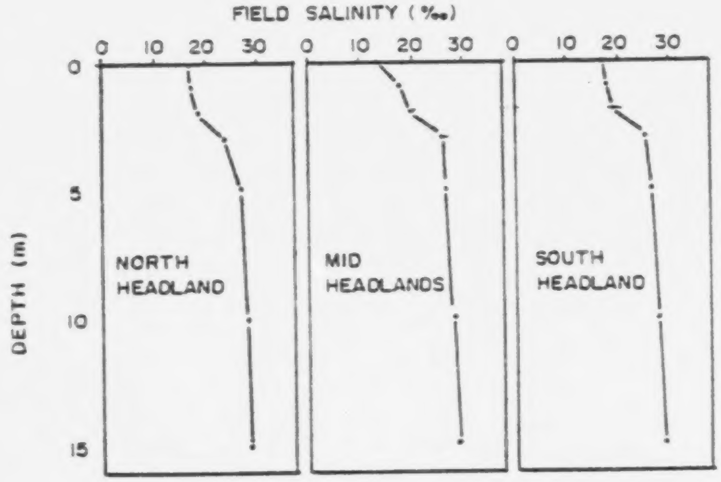
B. Devil Cove

In June, the freshwater flow from the river entering Devil Cove was mixed rapidly, resulting in a surface layer of moderate salinity (13.5 - 17.5^{o}/oo) which overlaid coastal waters of 29 - 30^{o}/oo (Figure 12). Salinities less than 10^{o}/oo were observed only within 10 m of the river mouth. As near as 30 m offshore, surface salinities had reached 16^{o}/oo. Estimated freshwater flows into Devil Cove for the sampling period are presented in Table 2.

Figure 12



A. LONGITUDINAL TRANSECT



B. TRANSECT BETWEEN HEADLANDS

SALINITY MEASUREMENTS IN DEVIL COVE, NEWFOUNDLAND
11 JUNE 1977

SOURCE: MacLaren Atlantic, 1977

In September, reduced salinities in surface water were observed at the river mouth and along the soutwest shore of the Cove (Figure 12). Salinities at 1 m depth were everywhere greater than 27°/oo. As these measurements were made under calm conditions prior to the onset of a gale, it is likely that average conditions of mixing would cause the low salinity layer to disappear.

Under low flow conditions in summer and winter, Devil Cove is virtually completely marine. The highly exposed nature of the Cove means that practically all existing flows are completely mixed. Estimated flows at the time of the September-October sampling, (0.5 m^3/s)(1), when practically no low salinity surface layer was observed, were 2.5 times higher than the low estimated February flows (0.2 m^3/s) (Table 2).

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(1) Estimated flows are calculated by multiplying gauged flows on the Cat Arm River for the period investigated by 0.032, a proportion arrived at from comparison of Devil Cove drainage area to the watershed area of the gauged flow.

3.2 Biotic Environment

3.2.1 Phytoplankton

Freshwater System

The phytoplankton communities of the Cat Arm watershed system are discussed by Airphoto/Beak (1976). Data were obtained during August, 1975 and provide the basis for discussion in this report.

The main Cat Arm Lake was typified by the presence of very few species and a moderately low biomass. The Chrysophyta were predominant and there was an especially large population of a small species of Chromulina. The Cynanophyta, or blue-greens were unusually abundant, accounting for 22% of the biomass. The total biomass in the main Cat Arm Lake was 111.8 mg/m^3, considered very low and well within the generally recognized oligotrophic range of less than 1000 mg/m^3 (Vollenweider, 1968)(Table 3).

The lakes to the south of Cat Arm Lake had populations with the Cryptophyta as the major group, with Cryptomonas erosa again being dominant. There were also fairly large populations of the Chrysophytes Chromulina and Mallomonas. The other algal groups were relatively unimportant. The total biomass from this southern basin was 127.6 mg/m^3, slightly more than in the main lake (Table 3).

Table 3

Freshwater Phytoplankton

Species	Near	Outlet	South	Inlet	North	Inlet
	$X10^3$ cells/ litre	mg/m^3	$X10^3$ cells/ litre	mg/m^3	$X10^3$ cells/ litre	mg/m^3
Cyanophyta						
Merismiopedia tenuissima	32.0	.1	71.2	.3	44.5	.1
Pelonema subtillisimum	2067.0	24.8				
Sub-total		24.9		.3		.1
Chlorophyta						
Ankistrodesmus falcatus			6.7	.3		
Chlamydomonas gloepara			1.8	.2	27.2	3.5
Elakatotrix gelatinosa	2.2	.2				
Oocystis lacustris			7.1	1.8		
Scenedesmus bijuga					3.6	.1
Sub-Total		.2		2.3		3.6
Chrysophyta						
Chromulina sp. 3.5u	557.6	41.8	442.0	22.1	584.8	29.2
Chromulina sp. 6u			102.0	10.2	142.8	14.3
Chrysochromulina parva	54.4	3.3				
Mallomonus acaroides	2.2	1.1				
Mallomonus alpina			9.8	11.7	1.8	2.1
Mallomonus producta			2.2	3.3		
Ochromonas sp. 5u	95.2	9.5				
Sub-Total		55.7		47.3		45.6
Bacillariophyta						
Asterionella formosa			12.5	1.5		
Tabellaria flocculosa			13.8	5.0	7.6	2.7
Sub-Total				6.5		2.7
Cryptophyta						
Cryptomonas brevis			2.2	4.4		
Cryptomonas erosa	13.4	24.0	24.9	44.9		
Cryptomonas erosa v reflexa	4.9	2.9	3.1	1.9	1.3	.8
Cryptomonas marssoni			6.7	17.3		
Rhodomonas minuta v nannoplanctica	40.8	4.1	27.2	2.7		
Sub-Total		31.0		71.2		.8
TOTAL BIOMASS		111.8)		127.6		52.8
(less pelonema		87.0				
Additional Species						
Anabaena circinalis						X
Ankistrodesmus falcatus						X
Ankistrodesmus spiralis						X
Arthrodesmus ralfsii						X
Asterionella formosa		X				X
Chlamydomonas sp. 7 X 4				X		
Chromulina sp. 9u		X		X		
Chrysamoeba mikrokonta		X				
Chrusamoeba sp.						X
Cryptomonas brevis						X
Cryptomonas caudata		X		X		
Cryptomonas erosa						X
Cryptomonas marssonii		X				
Cyclotella kuetzingiana				X		
Euastrum binale						X
Frustulia rhomboides						X
Katablepharis ovalis				X		
Katablepharis obalis		X				
Mallamonas alpina		X				
Melosira islandica		X		X		X
Microspora sp.						X
Mougeotia sp.						X
Navicula sp.						X
Ochromonas sp. 6 X 5				X		
Ochromonas sp. 3.5u		X				
Oocystis borgei		X				
Oscillatoria minima		X		X		
Peridinium inconspicum		X				
Rhodomonas lens				X		
Rhodomonas minuta v mannoplanctica						X
Sphaerocystis schroeteri		X		X		
Spondylosium planum				X		X
Synedra rumpens				X		X
Tabellaria fenestrata						X
Tabellaria flocculosa		X				

X denotes presence in sample

Source: Airphoto/Beak, 1976

The smaller ponds feeding Cat Arm Lake from the north were considerably poorer in biomass and species than the south inlet. The total biomass, was only 52.8 mg/m^3. The only group of any importance was the Chrysophyta, forming 86% of the total biomass. Two species of Chromulina, a small flagellate, were dominant (Table 3).

The live phytoplankton biomasses in all three main lakes were low and well within the oligotrophic category. The maximum seasonal biomass in most northern lakes is reached in late August or in September so it is probable that the samples obtained were at or near the seasonal maximum. The population and biomass estimates are similar to those obtained from Labrador lakes, Cape Breton Highland lakes and the less productive lakes of the Experimental Lakes Area of northwestern Ontario (Kling and Holmgren, 1972). The maximum biomasses in the Cat Arm area (around 125 mg/m^3) are slightly more than those from larger, unflooded Labrador lakes (Duthie and Ostrofsky, 1974), but slightly less than those from smaller, Cape Breton Highlands Lakes of similar colour and chemistry (Beak, 1976). The very low silica values in the Cat Arm area are probably responsible for the limited occurrence of diatoms in this area. The Cryptophyta and Chrysophyceae were the dominant or subdominant groups in the lakes of this area. This is in contrast to the Labrador studies of Duthie and Ostrofsky (1974), and the Beak studies (1976) on Cape Breton, where Chrysophyceae or diatoms were usually dominant.

A detailed list of all phytoplankton collected from the area is found in Tables 3 and 4.

Marine System

The phytoplankton of Great Cat Arm was distinctly estuarine and displayed major differences to that of Devil Cove. In June, the phytoplankton species compositions of Great Cat Arm and Devil Cove were distinctly different. Great Cat Arm has more species of flagellates and the estuarine and near coastal diatom, *Fragilaria islandica*, occurred there, but not in Devil Cove. Two diatom species (*Chaetoceros decipiens* and *Nitzschia longissima*) were present in the surface layer of Great Cat Arm, but absent in Devil Cove surface water. Two species of flagellates, *Gymnodinium* sp. and *Gyrodinium spirale*, found in low numbers in Great Cat Arm in June, were not observed in Devil Cove. These were the main representatives of the flagellate assemblage which predominated at the head of the Arm. In contrast, the abundant diatom species found at 20 m depth in Devil Cove formed a marine diatom assemblage.

In October, the Devil Cove phytoplankton assemblage was much more diverse than that of Great Cat Arm. As in June, the estuarine diatom *Fragilaria islandica* was observed in Great Cat Arm but not in Devil Cove. Only one other species of diatom (*Thalossiosira gravida*) was observed in Great Cat Arm but Devil Cove had four species.

Table 4

PHYTOPLANKTON SPECIES COMPOSITION AND ABUNDANCE (Numbers/l) FOR SELECTED WATER SAMPLES IN GREAT CAT ARM AND DEVIL COVE, NEWFOUNDLAND, JUNE AND SEPTEMBER-OCTOBER, 1977

Location	Devil Cove					Great Cat Arm			
Date	June 9			Sept 28		June 10		Oct. 1	
Station #						6		5	
Depth (m)	0	4.5	20	0	20	0	10	0	10
Diatoms									
Nitzschia longissima			23600	1960		840	7500		
Nitzschia seriata			23600		30				
Skeletonema costatum			67400						
Biddulphia sp.				2370					
Asterionella sp.				2050					
Fragilaria islandica						560		2640	
Fragilaria oceanica	16100	12100	460			23300			
Chaetoceros debile	22400	280	390			580	2900		
Chaetoceros decipiens		1900	380			130	7200		
Chaetoceros gracile		11900	53500						
Eucampia groenlandica	150								
Rhizosolenia delicatissima				90					
Rhizosolenia herbatata							60		
Thalassiosira gravida									10
Thalassiosira nordenskoldii	470	20	40				5050		
Pyrrophyta									
Amphidinium sphenoides			3920						
Ceratium longipes			40	180				100	90
Ceratium hirundinella				10					
Peridinium sp.		10					60		
Peridinium breve				20					
Gymnodinium sp.							40		
Gyrodinium spirale							140		
Dinophysis norvegica				70					
Cryptophyta									
Chilomonas sp.				372400					
Tintinnida									
Tintinnopsis sp.				10				10	30
Helicostomella subulata				30					
Acanthostomella norvegica									10

SOURCE; MacLaren Atlantic Ltd (1977)

Devil Cove had six species of flagellates to one in Great Cat Arm. It appears from this that a fall marine flagellate phytoplankton assemblage in the surface layer was not observed in Great Cat Arm as was the case in Devil Cove.

In both June and October samplings, the abundance of phytoplankton as cells/l was much higher at the mouth of Great Cat Arm than within it (Table 4). This could be a result of several factors, the most likely being light limitation by the highly humic surface freshwater outflow, and grazing by zooplankton.

In June, the abundance of phytoplankton (cells/l) and chlorophyll a (mg/l) at 10 m depth decreased between stations successively further out of the Arm but was still very high at the outer stations. Chlorophyll values were low relative to nearshore oceanic values and the correlation between cell numbers and chlorophyll a ($r^2=0.42$) was not statistically significant ($p < 0.10$).

In September-October, the abundance of phytoplankters increased between stations successively further out the Arm. Highest values were observed in the surface water at Station 6. Chlorophyll a followed a similar pattern and the correlation between cell numbers and chlorophyll a concentration was high ($r^2=0.88$) and statistically significant ($P < 0.04$).

Phytoplankton abundance in Devil Cove was high. In June, the highest numbers of phytoplankton occurred at 20 m depth and in October at the surface.

Cryptomonas mallomonas, *Chlamydomonas* and *Ochromonas*, all found in these waters, are easily digested. *D. catawba* is aestival and monoacmic. *Bosmina coregoni*, another important cladoceran, also feeds on nanoplankton and detritus. A detailed list of all zooplankton collected from the area is found in Table 5.

Table 5

Zooplankton

Cat Arm Ponds

Species/Sample Location	Near Outlet Biomass in mg/m^3	Near Outlet No./l	South Inlet No. per litre	North Inlet No. per litre
Cephalodella gibba				
Dicranophorus forcipatus		r	p	
Keratella choclearis	1.4	1.8	p	p
K. taurocephala	.9	1.2	p	p
Lecane lunaris			p	
L. methoria		r		
Lecane sp.				p
Ploesoma lenticulare			p	
Trichocera platessa			p	
CLADOCERA				
Acroperus harpae			p	
Alona quadrangularis			p	
A. guttata			p	
Alona sp.		r		p
Bosmina coregoni	.9	0.3	p	
B. longirostris			p	p
Chydorus sphaericus			p	p
Daphnia catawba	22.61	0.61	p	p
Daphnia sp.			p	
Eurycercus lamellatus			p	
Holpedium gibberum				p
COPEPODA				
Diaptomus sp.			p	
D. reighardi				p
Espichura lacustris				p
Nauplii	2.7	0.3		
MISCELLANEOUS				
Acari			p	
Chironomidae			p	
Ephemeroptera				
Oligochaeta				

r-rare
p-present but not quantified

SOURCE: Airphoto/Beak, 1976

The numerical abundance of phytoplankton was higher in October, but this was because many small dinoflagellates (Chilomonas sp.) were present. Concentrations of phytoplankton expressed as mg chlorphyll a/l (and thus direct estimates of biomass) were lower in October than in June.

3.2.2 Zooplankton

Freshwater System

At the time of sampling (late August), the numerical density of zooplanktors was about 3.7/l. This level is considerably below that reported by Davis (1973) for lakes on the Avalon Peninsula. The zooplankton population in the main lake was composed primarily of rotifers and cladocerans. The rotifers were numerically dominant, but the cladocerans were of much larger size and resulted in biomass dominance. One nauplii was found, probably Diaptomus reighardi with the only identifiable adult of this species being washed in from the southern part of the lake. Of the rotifers from the Cat Arm area, only Keratella taurocephala, K. cochlearis and Lecone (Monostyla) lunaris were found by Davis (1973) on the Avalon Peninsula.

The dominant cladoceran collected from this area was Daphnia catawba. This species is characteristically lacustrine and is the only North American species limited to the Atlantic coast and the adjacent eastern part of the continent. It feeds on small delicate flagellates, detritus and bacteria.

The overall biomass of zooplanktors in these waters was less than that found in the other eight interio Newfoundland lakes investigated in August, 1975 (Airphoto/Beak, 1976). Cat Arm Lake can be classified as having a very low standing stock of zooplanktors. Part of the reason for this is a very low rate of nutrient cycling, a high flushing rate and intense predation by trout.

In all of the samples from both the Cat Arm area and other areas of Newfoundland investigated during this study, neither ephippial females nor ephippial eggs were found among the cladocera. This generally indicates that the population is in its growing phase and not declining.

Many of the heterotrophic and nutrient restraints discussed in the section on phytoplankton apply equally to the zooplankton populations of the Cat Arm area. In spite of the large amount of organic carbon present in these waters, (averaging 56 mg/l) the amount present as phytoplankton is only in the range of 5 mg/m^3 and the amount as zooplankton, 2 mg/m^3, for a total biomass value of 7 mg/m^3 or .012% of the total carbon pool. These figures emphasize that, although there is a very large energy pool of organic carbon in this watershed, very little of it is being translated into plankton standing stock. The reasons for this appear to relate to the very low nutrient levels and high flushing rates which wash populations out of the lakes before they have time to build-up.

Marine System

In June, the water column in Great Cat Arm contains mainly copepods, in order of abundance: Pseudocalanus minutus copepodites (63.6%), Thysanoessa sp. (euphausiid) nauplii, metanauplii and calyptopis stages (17%) and Cirripede (barnacle) nauplii (9.7%). The remaining 10 percent of the individuals present are first, second and third stage Calanus finmarchicus, adult Oithona similis, adult Pseudocalanus minutus and Temora longicornis adults and copepodites (Table 6). Early stages of several of the species predominate. Reproduction of herbivorous zooplankters is usually timed so that young can utilize peak phytoplankton productivity, in this case, the spring bloom.

The same species are present again in September (Table 6). In each of the zooplankton tows analyzed, near the estuary head and along the estuary, species which were present in June as young stages occur in September as late to adult stages. This is the case for the predominant copepods, Calanus finmarchicus, Pseudocalanus minutus and Temora longicornis, and the euphausiid Thysanoessa inermis. Adults of several species occur in September, but were not sampled in June. These included the copepods Acartia longiremus and Tortanus discaudatus and the pteropod (sea butterfly) Limacina helicina.

The Devil Cove zooplankton in June is dominated by euphausiid early stages, especially nauplii and mentanauplii (80.2%). The species was

Table 6

ABUNDANCE (Number/m^3) AND PERCENTAGE COMPOSITION OF ZOOPLANKTON IN GREAT CAT ARM AND DEVIL COVE, NEWFOUNDLAND

Location	Great Cat Arm			Devil Cove	
Station #	1	1-2	4-5	1	1
Date	June	September	September	June 9	Sept. 29
Volume Filtered (m^3)	2.2*	83	1096	124	169
CNIDARIA					
Aglantha digitale		P	P		
CTENOPHORA					
Beroe cucumis		P			
Mertensia ovum			*		
GASTROPODA					
Clione limacina				*	
Limacina helicina		179(11.4)	5(3.0)		
Limacina helicoides					35(2.1)
APPENDICULARIA					
Oikopleura labradoriensis		59(3.7)	2(0.9)		11(0.7)
Oikopleura dioica				99(1.9)	
EUPHAUSIACEAE					
Thysanoessa inermis furciliae		P	P		
Nauplii and Metanauplii	4364(15.5)			4195(90.2)	
Calyptopis stages	698(2.5)			231(4.4)	
CHAETOGNATHA					
Sagitta elegans		P	P	5(0.1)	
DECAPODA					
Pandalus larvae			P		
Brachyuran zoeae			P		
CIRRIPEDIA					
nauplii	2735(9.7)		45(0.9)		
COPEPODA					
Calanus finmarchicus					
↔		69(4.4)	25(14.1)		67(4.3)
←		25(1.6)	3(1.9)		32(1.9)
CV		111(7.1)	36(20.9)	8(0.2)	173(10.2)
CIV		19(1.2)	11(6.3)	12(0.2)	54(3.2)
CIII	175(0.6)	3(0.2)	1(0.5)	33(0.6)	10(0.6)
CII	640(2.3)				
CI	465(1.7)				
Calanus glacialis ←					3(0.2)
CV					3(0.2)
Centropages hamatus					
↔			P		
Oithona similis	465(1.7)	20(1.3)	4(2.2)	240(4.6)	26(1.5)
Pseudocalanus minutus ↔	291(1.0)	17(1.1)	2(0.9)		51(3.0)
←	58(0.2)				6(0.4)
Copep.	17920(63.6)	77(4.9)	4(2.6)	33(0.6)	896(53.2)
Temora longicornis					
↔	58(0.2)	102(6.5)	37(21.5)		118(7.0)
←		86(5.5)	20(11.6)		42(2.5)
Copep.	116(0.4)	765(48.8)	13(10.4)		134(9.1)
Unidentified harpacticoid	116(0.4)				
Acartia longiremis ←		17(1.1)	1(0.8)	91(1.7)	
↔			P	12(0.2)	
Copep.		9(0.6)	2(1.1)	231(4.4)	
Tortanus discaudatus					
↔		6(0.4)	1(0.4)		
←		2(0.1)	1(0.4)		

KEY

P = Species percentage less than 0.1%

() = percent of total

↔ = female

← = male

* = Vertical plankton tow

SOURCE: MacLaren Atlantic Ltd (1977

unidentified, but it was presumed to be Thysanoessa inermis, as this is the only species identified from later stage specimens sampled in the area. The copepods Acartia longiremis (largely copepodites), Oithona similis, Pseudocalanus minutus and Calanus finmarchicus (copepodite stages 3 to 5) and an appendicularian Oikopleura dioica are present in about equal abundance.

In September-October, Pseudocalanus minutus copepodites predominate (53.1%) followed in abundance by Temora longicornis copepodites and adults (18.6%) and mid-stage to adult Calanus finmarchicus. The copepod Oithona similis, the pteropod Limacina helicoides and the appendicularian Oikopleura labradoriensis are present in low numbers.

Early stages of the copepod Calanus finmarchicus were present in June with the adult and late stages occurring in the fall. Young stages of the copepod Acartia longiremis and the euphausiid Thysanoessa inermis were present in June, but adults were not sampled in the fall.

3.2.3 Marine Benthic Invertebrates

The inner part of Great Cat Arm is an impoverished estuarine environment deficient in animal and plant life. A detailed account of intertidal invertebrates sampled along transects is presented in MacLaren (1978). Shoreline transects showed a low diversity and abundance of animals. Only intertidal amphipods (Gammarus oceanicus) and snails (Lacuna vincta), marine species more tolerant of freshwater, were to be found hidden under stones on the beach. Small numbers of sea stars (*Asterias vulgaris*) and sea urchins (*Strongylocentrotus droebachiensis*) were found below the freshwater-seawater interface. The low abundance of subtidal marine invertebrates at the head of the estuary may be explained by low survival of pelogic larvae in waters of reduced salinity.

Further seaward along Great Cat Arm, the salinities near the shore are higher, and showed an increased incidence of marine intertidal animals. Animals which are more strictly marine, in addition to those mentioned already, the periwinkle (*Littorina littorea*), hermit crabs (*Pagurus pubescens*), and cancer crabs (*Cancer irroratus*), occured below the pycnocline. Mussels (*Mytilus equlis*) also occured at about pycnocline depth. (Barnacles (*Balanus balanoides*) appeared in the intertidal zone.

In terms of diversity and abundance the richest intertidal and subtidal marine invertebrate fauna is to be found further out the Arm where barnacles, mussels and the amphipod *Gammarus oceanicus* were present.

The intertidal fauna of Devil Cove is typically marine. Its distribution along the shore is probably a result of wave exposure. Major intertidal marine invertebrate species, such as barnacles, mussels, small littorinid gastropods (*Littorina saxatilis*) and amphipods (*Gammarus setosus* and *G. oceanicus*) were found over most of the cove shoreline. All species (excluding the amphipods which hid under beach stones) were absent from the fine cobble beach at the inner portion of the cove. At either end of the beach, the fauna reappeared with the occurrence of large boulders.

In general, L. *saxatilis* occurs highest on the shore, followed closely by barnacles and mussels in protected crevices. Amphipods are associated with macrophytes. The first sublittoral species (sea stars and sea urchins) occur about 1 m below mean low water. A band of sea urchins extends to a depth of 5 - 6 m where it is replaced by sea anemones (*Metridium senile*) on rocks.

3.2.4 Intertidal and Subtidal Macroalgae

Few species of intertidal and littoral macroalgae occur at the head of Great Cat Arm. Only the epiphytic brown filamentous alga *Pilayella littoralis* occurs at the extreme head of the estuary. Stunted *Fucus vesiculosus* is found subtidally quite far in the Arm. These species are freshwater tolerant and can grow at reduced salinities. *Ascophyllum nodosum* occurs in towards the head of Great Cat Arm. Plants above mean low water are generally reduced in size over those occurring deeper. Specimens of F. *vesiculosus* at mean low water are black, brittle and stunted. On the outer transect, typically-marine species like *Chordaria flagelliformis*, *Rhizoclonium* sp., *Chorda filum*, *Ectocarpus* sp. and *Desmarestia aculeata* are found in abundances similar to that of Devil Cove.

Fucus vesiculosus and Porphyra sp. are the predominant macro-algal species in the intertidal zone of Devil Cove. These species do not occur in the beach zone in the central part of the cove where wave action precluded even the occurrence of most intertidal animals.

Algae such as Chordaria flagelliformis, Chorda filum and Desmarestia aculeata occurs in a narrow band just below mean low water in most parts of the cove. At the cove head, Asperococcus fistulosus is abundant just below mean low water. The narrow band of brown algae just below mean low water forms a conspicuous crescent-shaped mat on the shallow sloping beach subtidal zone. Below this zone, in all areas of the cove can be found clumps of: red algae such as Polysiphonia sp. and Ceramium sp.; green filamentous Cladophora sp., Rhizoclonium sp., and green Ulva sp.; and Ulvaria sp. Laminaria sp. occur sporadically in the immediate subtidal. Agarum cribrosum is a predominant subtidal algae at depths greater than 6m at all sampling sites.

3.2.5 Fish

A. Species Composition and Distribution

Species composition reported by Beak (1980) confirms the earlier findings of Airphoto/Beak (1976), i.e., the fish fauna of the Cat Arm watershed comprise freshwater brook trout, sea-run trout, Atlantic salmon, and American eel. Due to major barrier falls at the mouths of the Cat Arm River and Devil Cove Brook, species presence above the falls is limited to resident brook trout.

Resident brook trout are the dominant, most widely distributed species in the Cat Arm watershed, being found in all the lakes and streams sampled.

Sea-run brook trout and Atlantic salmon were collected from the pool below the falls at the mouth of the Cat Arm River. The presence of juvenile salmon confirms a succession of successful spawning over a three year period.

American eels were taken from the Devil Cove brook below the first barrier falls and in the mouth of the Cat Arm River. No samples were taken above these barriers and neither was there evidence of eel damage in any of the gillnet catches within the freshwater system.

No other fish species are present within the Cat Arm watershed. The absence of any forage species such as stickleback is important.

Habitat

In assessing rearing or nursery habitat for juvenile brook trout and Atlantic salmon, it is usually assumed that the bulk of spawning of these species occurs in river or stream habitat and that, in comparison with standing water, stream habitat has a much higher productivity of juvenile salmonids, particularly in the early years (0+ to 2+ age).

Good salmonid rearing habitat comprises relatively shallow river or stream with moderate current and good cover (Type 2 Habitat). If there is gravel or fine cobble substrates distributed throughout the section, it is classified as good spawning habitat (Type 1 Habitat). Experience has shown that if gravel and fine cobble comprise a high proportion of the substrate, then cover may be reduced and its value as rearing habitat lessened. High gradient sections of rivers with a preponderance of rapids and waterfalls may contain good holding habitat for adult salmonids but are of inferior quality for juvenile fish (Type 3 Habitat). Low gradient sections with low current velocities, fine sediments and above average depths are also considered to be inferior rearing habitat (Type 4 Habitat).

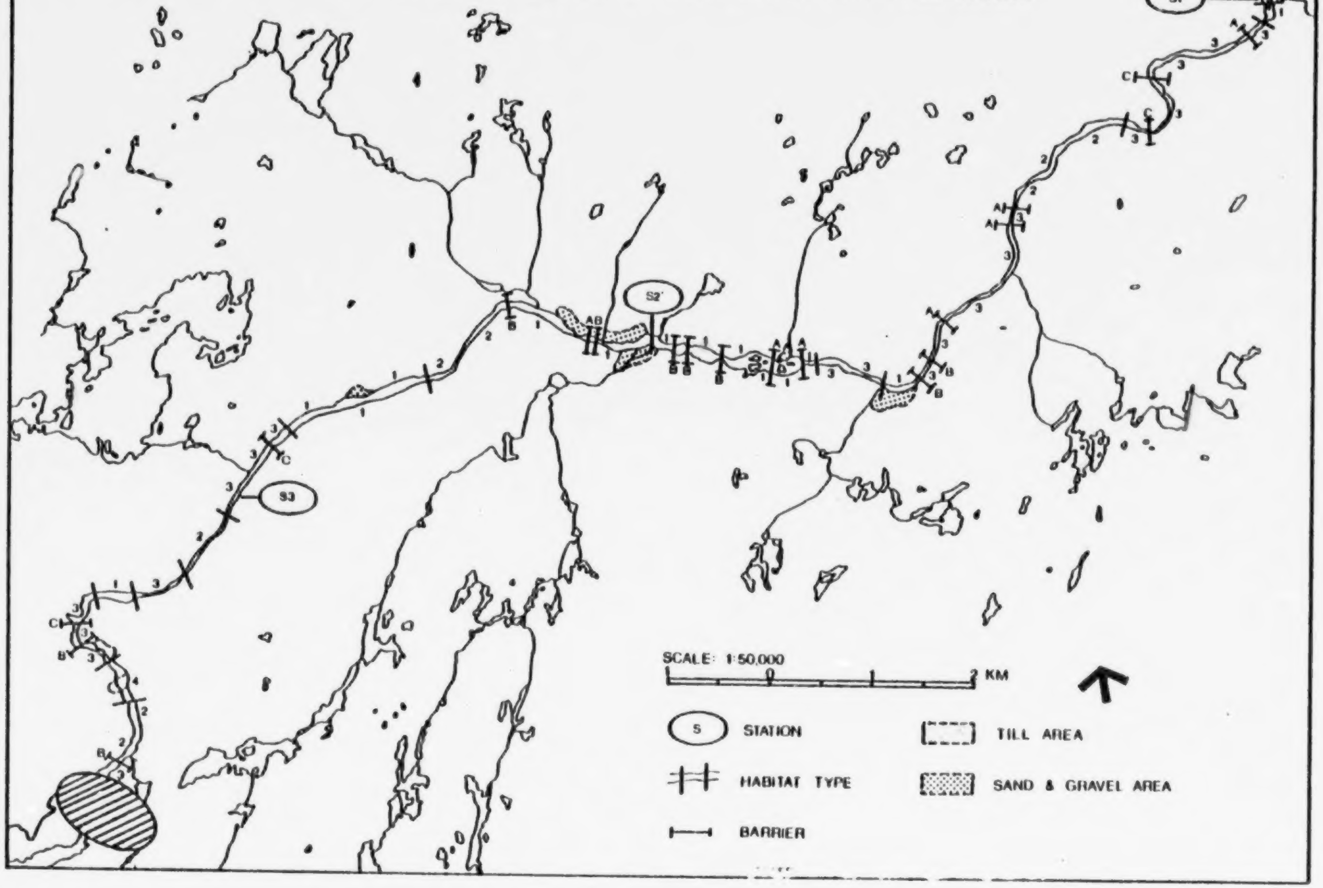
In the study area, good rearing habitat may be considered to be equally valuable for both brook trout and Atlantic salmon, although there are important differences in the requirements of the two species (Gibson 1966, 1973). The same habitat classification was used for both the Cat Arm River, downstream of the dam, and for the smaller tributaries on the plateau although it must be noted that there may be substantial differences in rearing habitats related to the relative sizes of the rivers.

An assessment of the degree of severity of barriers (waterfalls) was also completed. Observations were made at only one discharge level and judgements were not confirmed by actually observing the behaviour of fish relative to the barriers. Barriers were classed as being Grade A - complete prevention of passage, Grade B - passable for large salmonids at some discharge levels, and Grade C - passable for adult salmonids at most levels of discharge.

For the purposes of describing salmonid habitat in the study area, the system can be divided into three sections: the Cat Arm River below the dam; the core section of larger lakes lying on the plateau and within the reservoir zone; and the tributary system feeding the lakes and lying largely outside the reservoir zone. The Cat Arm River below the dam (Figures 13 and 14) passes from the plateau down the escarpment to sea level losing a total of 360 m of elevation over about 18 km. Consequently, it contains large stretches of rapids and waterfalls (3800 units Type 3 Habitat) (Table 7) and few still-water sections (300 units of Type 4 Habitat).

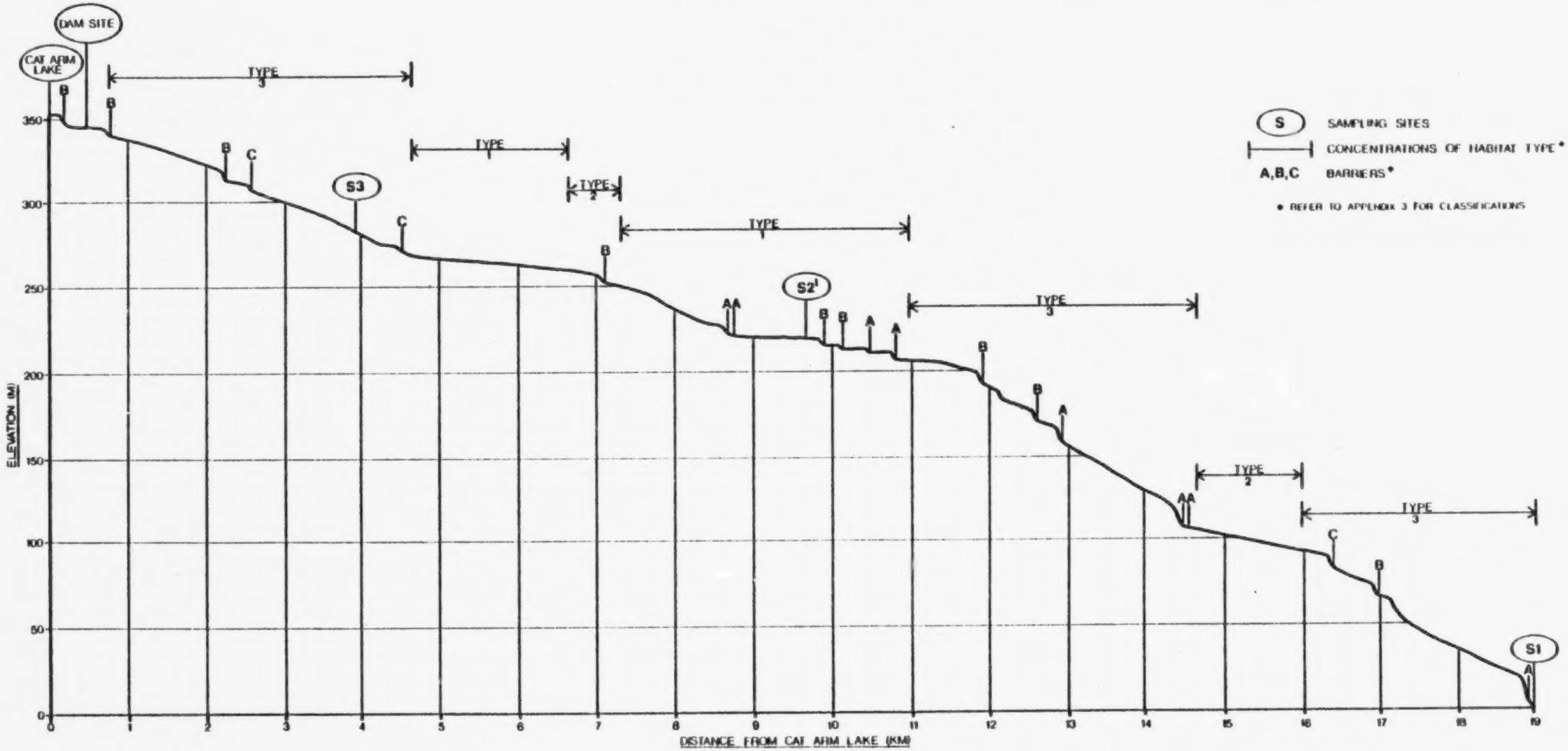
Barriers ranging from Grade C to Grade A waterfalls occur throughout the length of the river. Of the total of 9800 units of habitat estimated to occur in this section of river, about 60% or 5700 units are considered to be good rearing habitat for juvenile salmonids and about two-thirds of this contain substantial spawning habitat. The value of this habitat for migratory populations however, is offset by the large number of barriers in the river. Beak estimated that there are eight Grade A barriers and nine Grade B barriers distributed throughout the length of the Cat Arm River including a Grade A barrier (23m) just upstream from Great Cat Arm River, and two Grade B barriers just below Cat Arm Lake (L6). These falls effectively isolate the river from the sea and the plateau. Consequently

FIGURE 13
DISTRIBUTION OF SALMONID REARING HABITAT IN THE LOWER CAT ARM RIVER.


GREAT CAT ARM
S1
S2
S3
SCALE: 1:50,000
0
2 KM
S STATION
HABITAT TYPE
BARRIER
TILL AREA
SAND & GRAVEL AREA

SOURCE: Beak, 1980

FIGURE 14
GRADIENT PROFILE OF THE CAT ARM RIVER SHOWING THE LOCATION OF BARRIERS AND CONCENTRATIONS OF HABITAT TYPES.



SOURCE: Beak, 1980

Table 7

Salmonid rearing habitat (units) in the Cat Arm River and its tributaries

Habitat Type Tributary	1	1/2	2	2/3	2/4	3	3/4	4	Total
Cat Arm River	3,800		1,875			3,800		300	9,775
Reservoir Streams									
South branch			950			100	400	2,375	3,825
North branch			1,275			750	300	3,350	5,675
Total			2,225			850	700	5,725	9,500
North Tributary System									
T1		100	1,265		275			2,625	4,265
T2			360					70	430
T6			570	630				150	1,350
Total		100	2,195	630	275			2,845	6,045
South Tributary System									
T3			1,315			200		4,380	5,895
T4	65		720		480			275	1,540
T5	60		1,200			940		2,000	4,200
Total	125		3,235		480	1,140		6,655	11,635
Total	3,925	100	9,530	630	755	5,790	700	15,525	36,955

SOURCE: Beak, 1980

the good rearing habitat in the Cat Arm River is only utilized by semi-isolated resident populations of brook trout.

Only about 200-300 m of the Cat Arm River is accessible to anadromous stocks of brook trout and Atlantic salmon. Below the barrier falls there is a large pool with three channels to the sea (Figure 15). The left-hand channel carries only peak discharge. the middle channel carries peak discharge plus a portion of low summer flows. The right-hand channel is shielded from higher flows but still carries up to one-half of low summer flows. This latter channel contains a mixture of small pool and riffle habitat with a gravel substrate, and is considered to be first class salmon rearing habitat. A gravel bar fan at the downstream end of the large pool provides excellent spawning habitat. The total area of rearing habitat for anadromous salmonids is estimated to be about 160 units or about 2% of the rearing habitat in the Cat Arm River (Figure 15) (Beak, 1980 b).

Above the dam on the plateau, the Cat Arm system (Figure 16) divides into northern and southern tributary systems both of which flow into Cat Arm Lake (L16) just upstream from the dam. The area within the reservoir zone contains a high concentration of lakes (22% of reservoir area). There are 11 large lakes up to 150 ha in surface area, and numerous smaller lakes and ponds. The lakes are relatively shallow and have a high shoreline development factor. Substrates are primarily bedrock and boulder and there are numerous clean, shallow bedrock shoals that could be utilized by brook trout for spawning purposes.

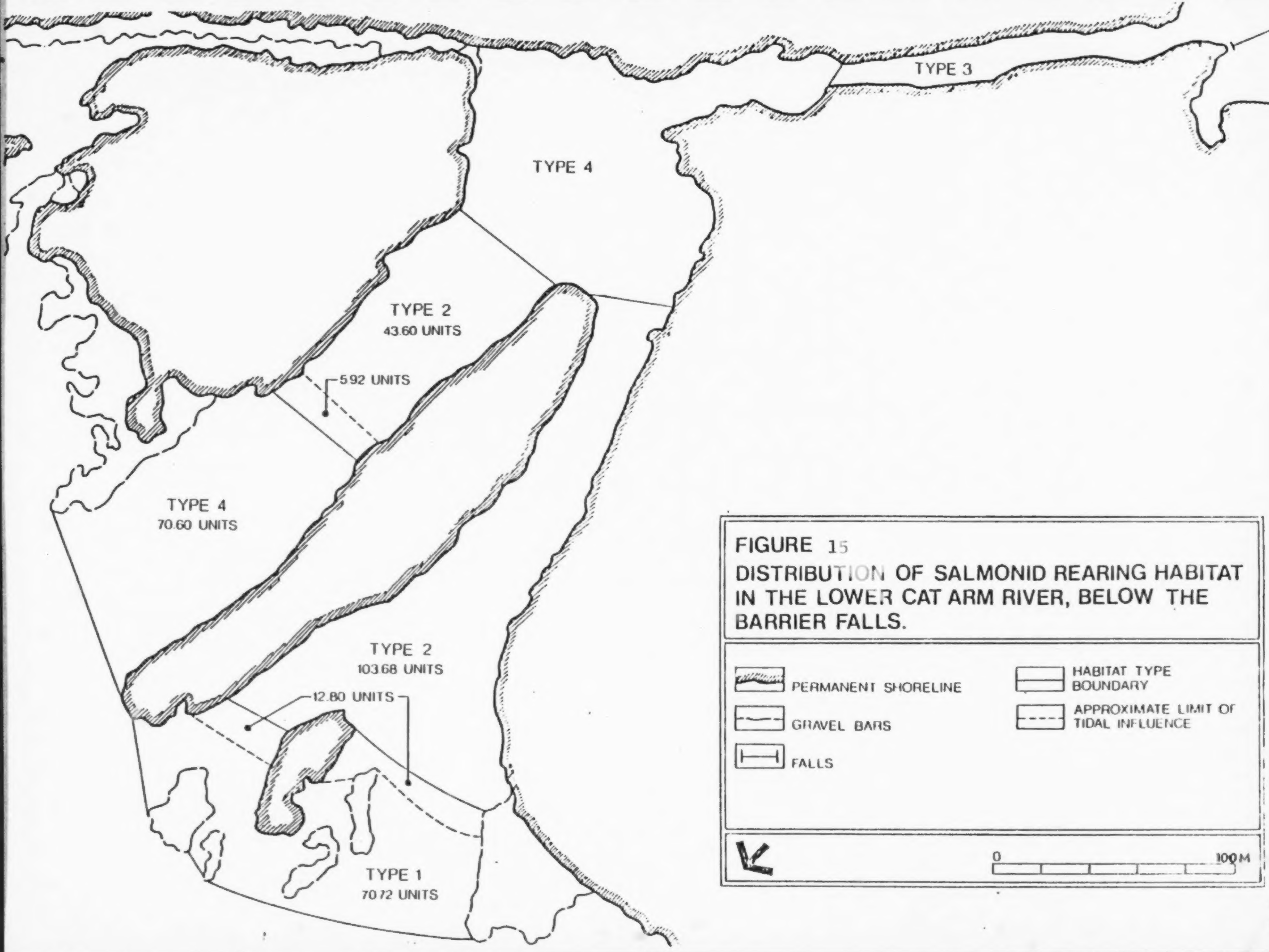

TYPE 3
TYPE 4
TYPE 2
43.60 UNITS
5.92 UNITS
TYPE 4
70.60 UNITS
TYPE 2
103.68 UNITS
12.80 UNITS
TYPE 1
70.72 UNITS
PERMANENT SHORELINE
GRAVEL BARS
FALLS
HABITAT TYPE BOUNDARY
APPROXIMATE LIMIT OF TIDAL INFLUENCE
0
100 M

FIGURE 15
DISTRIBUTION OF SALMONID REARING HABITAT IN THE LOWER CAT ARM RIVER, BELOW THE BARRIER FALLS.

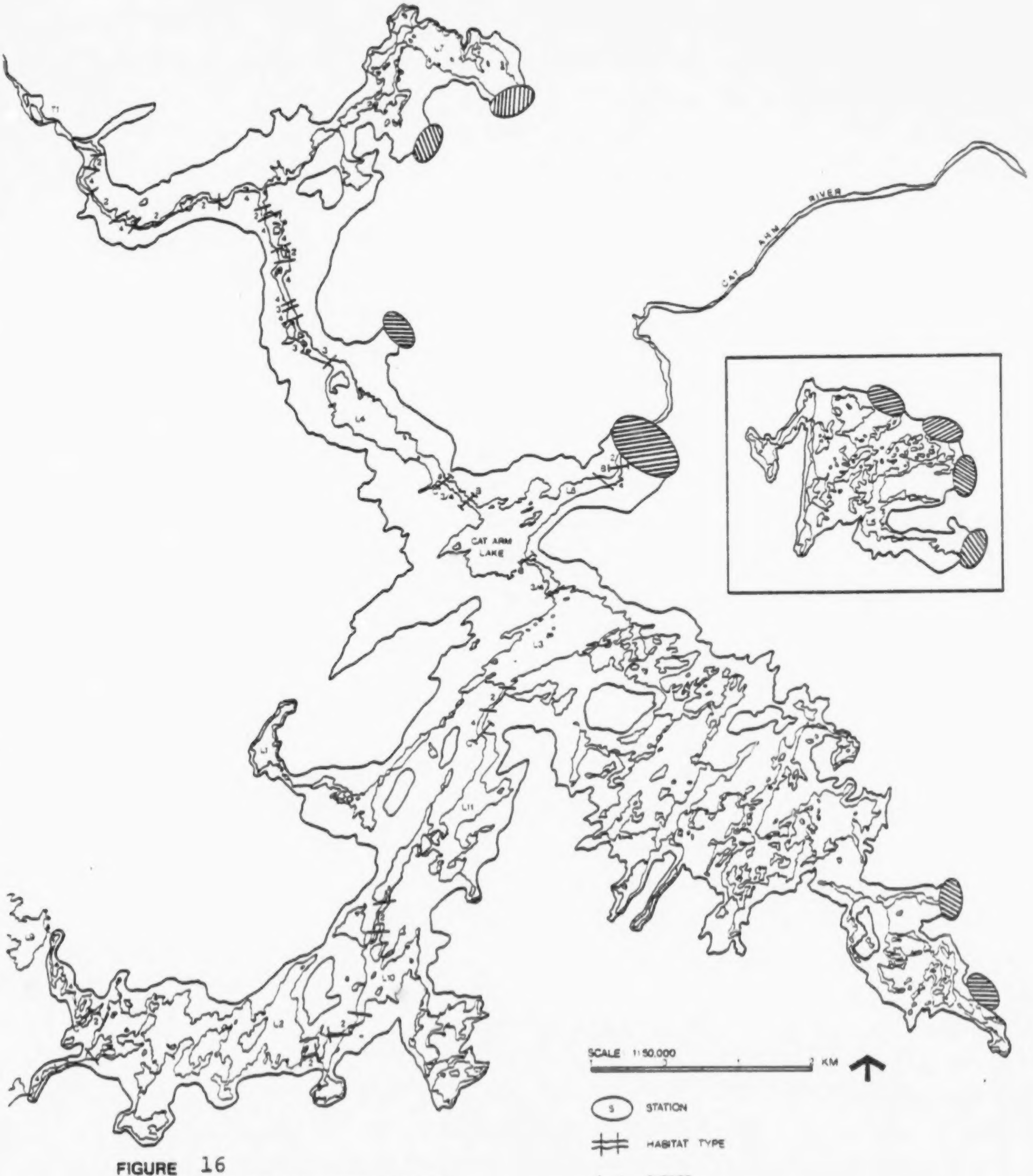

CAT ARM RIVER
CAT ARM LAKE
SCALE 1:50,000
KM
STATION
HABITAT TYPE
BARRIER

FIGURE 16
DISTRIBUTION OF SALMONID REARING HABITAT IN THE RESERVOIR ZONE.

SOURCE: Beak, 1980

Results of the gillnetting survey suggest that lake spawning occurs in Lake 1. Electrofishing of the shoreline in Cat Arm Lake (L16) revealed the presence of 0+ and 1+ brook trout residing in the shallow littoral zone. The quality of the spawning and rearing habitat in the lakes, the presence of juvenile brook trout, and the relative isolation of some of the lakes from any significant quantities of stream rearing habitat all suggest that lake spawning may be of some importance within the reservoir zone.

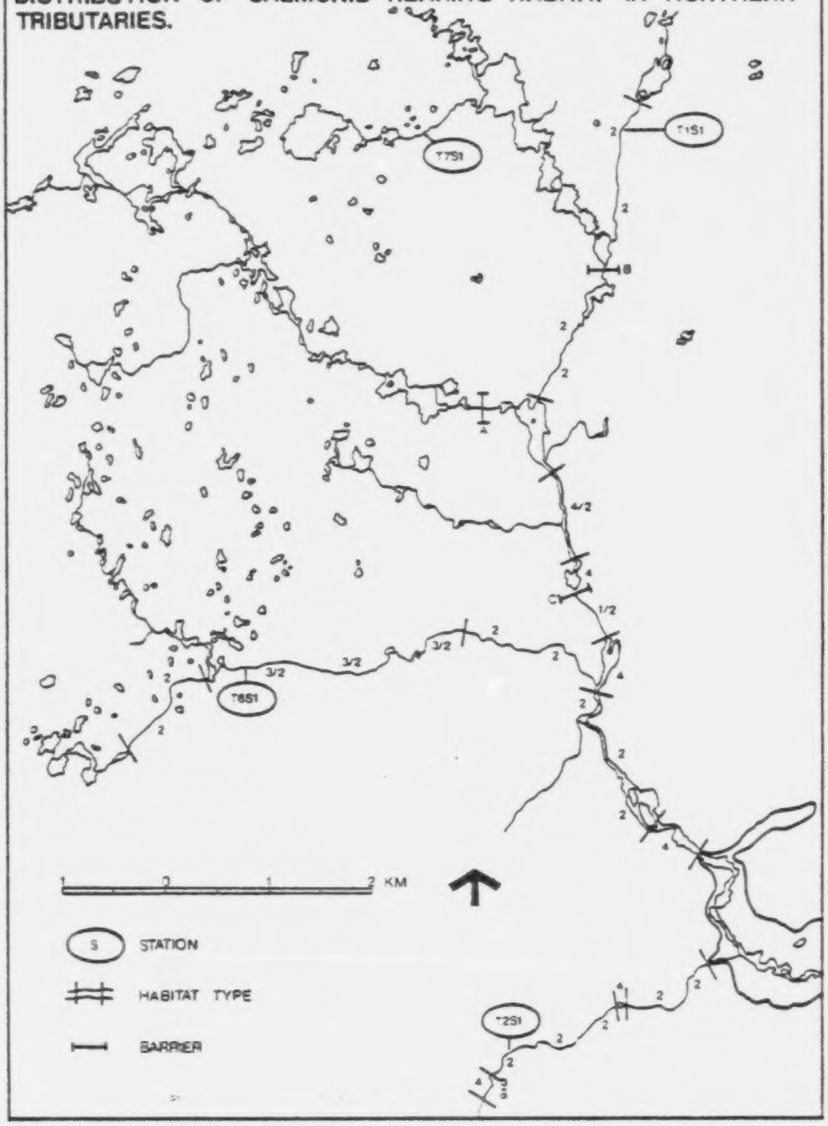
The lakes within the reservoir zone are connected by very short sections of the north and south branches of the Cat Arm River. The channels of the two branches cross the bedrock outcrops which divide the various lake basins, thus small falls, usually Grade C or B barriers often occur between the lakes and these may act to isolate trout populations. For example, Grade B barriers occur on both branches of the river just above Cat Arm Lake (L6). There is very little gravel or fine cobble substrate in these sections of river and none of the habitat in the two branches was classed as Type 1 (Table 7). A rough assessment of habitat in the two branches within the reservoir zone indicated that about 23% or 2200 units of the stream habitat was Type 2 rearing habitat. There is additional rearing habitat in about 30 minor drainages entering the main branches of the river and the lakes.

Above the reservoir zone there are fewer large lakes although there are many smaller lakes and ponds within the channels of the main tributary systems. The north branch of the Cat Arm River

(Figure 17) drains the north-west portion of the study area beyond the reservoir zone via one major tributary (T1) with several feeder streams (T2, T6, T7 and others). The south branch of the Cat Arm River (Figure 17) drain the south-west portion of the study area beyond the reservoir zone via three tributaries (T3, T4, T5). These tributary systems consist of intermittent sections of riffles and still-water. The majority of the rearing habitat is classed as Type 2 or Type 4. Quantities of rearing habitat were estimated for the larger streams. The northern system was estimated to contain 2200 units of Type 2 rearing habitat and 100 units of Type 1/2 habitat (Table 7). The southern system was estimated to contain a further 3200 units of Type 2 habitat and 125 units of Type 1 habitat. The low quantities of Type 1 rearing habitat suggest that spawning habitat has the potential to be a limiting factor, and that brook trout rather than utilizing a few major spawning beds probably spawn in numerous sites (pocket spawning) scattered throughout the tributary streams, and in the lakes. There are additional smaller quantities of spawning and rearing habitat in many minor drainage systems which enter the reservoir zone elsewhere.

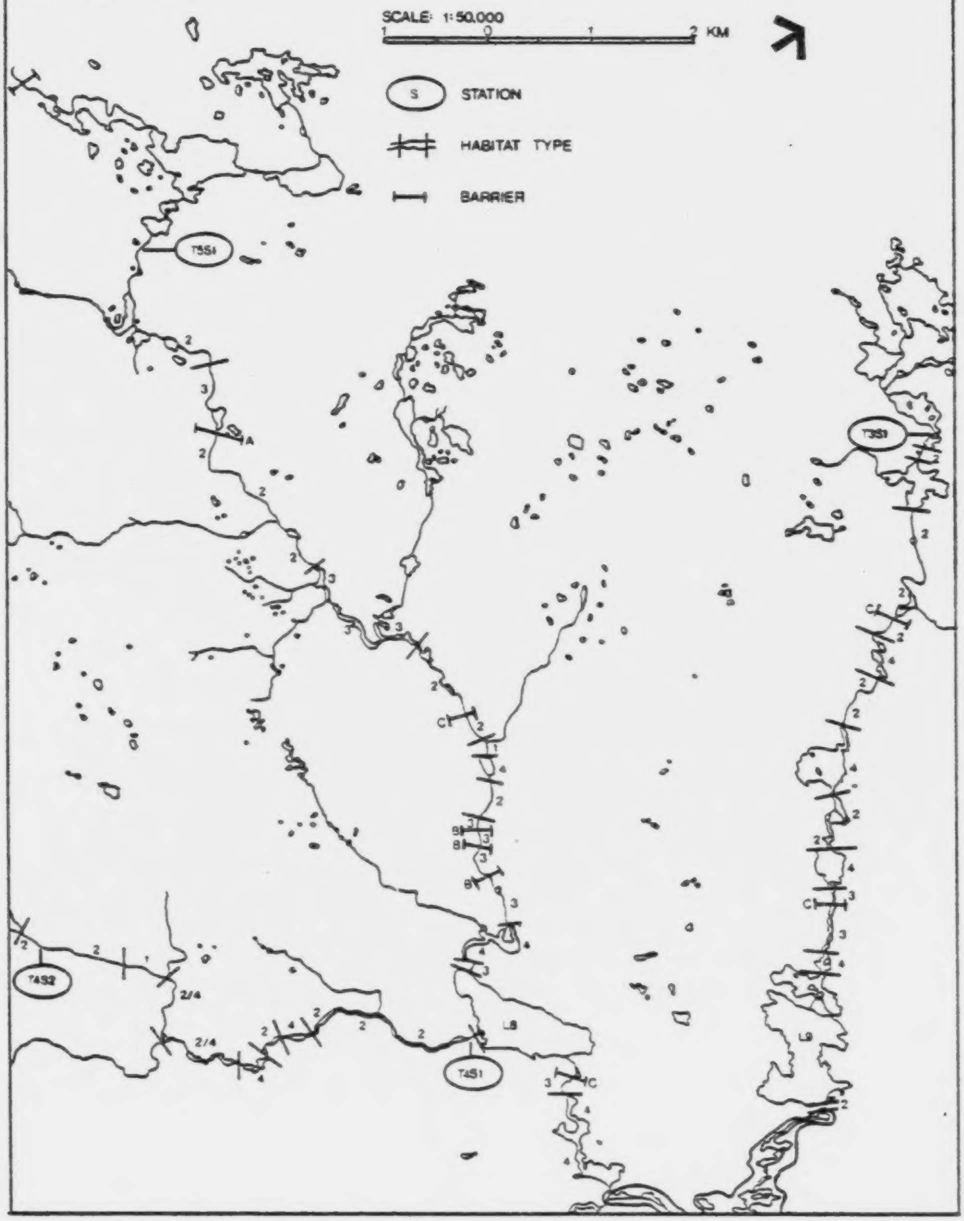
There are some low waterfalls on the major tributaries which may act as complete or partial barriers to fish movement (Figures 17 and 18). Several C barriers are located at strategic locations near the FSL of the reservoir, but it appears likely that even small brook trout that reside in the study area could negotiate these barriers if there was a migratory urge to do so. One such Grade C

FIGURE 17
DISTRIBUTION OF SALMONID REARING HABITAT IN NORTHERN TRIBUTARIES.


T7S1
T1S1
T6S1
T2S1
B
A
C
2
4/2
4
1/2
3/2
1 0 1 2 KM
S
STATION
HABITAT TYPE
BARRIER

SOURCE: Beak, 1980

FIGURE 18
DISTRIBUTION OF SALMONID REARING HABITAT IN SOUTHERN TRIBUTARIES.


SCALE: 1:50,000
1
0
1
2 KM
S
STATION
HABITAT TYPE
BARRIER
T5S1
T3S1
T4S2
T4S1
L8
L9

SOURCE: Beak, 1980

barrier just downstream of Lake 8, is strategically located just below the FSL and would normally be exposed during the brook trout spawning season. The most serious barriers (Grade B) occur on Tributary 5 just upstream from L8 and above the FSL. These could quite possibly block the upstream movement of all brook trout.

A comparison of the quantities of good rearing habitat in the Cat Arm River below the dam, in the reservoir zone, and in the north and south tributary systems above the reservoir zone is presented in Table 10. Virtually all of the Type 1 rearing habitat (3900 units) is found in the river below the dam. Roughly equivalent amounts of Type 2 habitat (1900 - 3200 units) are found in the tributary system. The total assessed salmonid rearing habitat (Type 1 and 2) in the whole system is about 14,900 units. The Resource Development Branch of the Fisheries and Marine Services has estimated that the potential salmon rearing habitat in the Cat Arm River and its tributaries is about 11,300 units (Porter et al, 1974). Given the accuracy of habitat assessment surveys these estimates are quite close.

The aquatic habitat of the forebay zone consists of a group of small lakes and ponds connected by a system of small streams. The lakes are very shallow, dotted with islands and shoals, and have a high ratio of shoreline to surface area. Spawning and rearing habitat probably exists within the lakes.

Table 8

Approximate estimates* of brook trout standing stocks in good rearing habitat (Type 1 and 2) in the rivers and streams of the study area

	Type 1 and 2 Habitat (units)	Standing Stock Numbers	Biomass (kg)
Location			
Cat Arm River below the dam	5,700	84,000	850
Reservoir streams	2,900	43,000	430
Tributary streams above the reservoir	3,800	56,000	570

*Estimates are subject to numerous errors and qualifications as discussed in the text.

SOURCE: Beak, 1980

Table 9

Minimum Standing Stock and Delury estimates for brook trout sampled from the Cat Arm watershed

Station	Area m^2	Number of runs *	Minimum Standing Stock per 100 m^2		Delury Estimation per 100m^2		R^2 for regression	
			catch (nos)	biomass(g)	catch(nos)	biomass(g)	catch	biomass
S-2	193	3	13.5	161.1	16.1	162.7	.59	.5
S-3	231	2	3.9	31.4	4.2	39.5	-	
T1S1	242	4	19.4	169.1	22.6	177.0	.75	.8
T2S1	281	4	8.5	133.6	10.0	167.9	.80	.7
T3S1	168	3	19.6	224.9	21.4	254.2	.99	.7
T4S2	140	3	17.1	163.2	17.4	193.3	.99	.7
T5S1	124	3	30.7	159.4	35.0	169.1	.90	.8
T6S1	118	3	14.4	183.2	17.2	222.1	.92	.6
T7S1	253	2	2.8	75.5	3.3	78.1	-	
T8S1 (Cat Arm Lake)	273	2	6.6	76.7	6.6	78.9	-	
Devil Cove Tributary	238	3	8.0	94.9	8.1	105.3	.99	.9
range			2.8-30.7	31.4-224.9	3.3-35.0	39.4-254.2		
$\bar{X}$, S**			13.4,8.31	133.91,57.37	14.72,9.52	149.83,66.29		

*Electrofishing runs counted as one unit of effort each.
**S=Standard deviation

SOURCE: Beak, 1980

Brook Trout Abundance

Stream Populations

The catch of trout at 11 sampling sites located in streams or the main river is presented in Table 8 and the Delury estimates arrived at from these data are shown in Table 9. DeLury estimates ranged from 3 to 35 trout per unit (40-250 g/unit) at the 11 stations. Since all stations had been located in Type 2 rearing habitat, a single mean standing stock (15/unit, 150 g/unit) has been calculated for all Type 2 rearing habitat. This estimate is compared to mean estimates for several other study areas in Newfoundland, Labrador and northern Quebec (Table 10).

Table 10

Some standing stock estimates (/unit) of salmonids in rivers of eastern Canada

	brook trout		Atlantic salmon		all species	
	no.	g	no.	g	no.	g
Labrador						
Naskaupi River (LeDrew 1972 MS)	9	118	0.2	2	22	198
Lower Churchill tributaries (Beak, 1979)						
accessible river	7-8	21-55	-	-	15	59-87
inaccessible river	12	115	-	-	17	189
Newfoundland						
Cat Arm tributaries	15	146	-	-	15	146
Hinds Lake-Goose Brook (Lewis 1979 MS)	13	108	0.8	36	14	134
West Salmon River (Beak 1979 MS)	7	-	72	126	77	177
White Bear River (LeDrew 1973 MS)	0-14	0-121	0-7.2	0-108	0.4-14	10-121
Northern Quebec						
Tchinicaman River (O'Connor 1976)	19	130	-	-	19	130

SOURCE: Beak, 1980

In Table 8, the mean estimate for standing stock at the 11 sampling sites has been extrapolated to arrive at an estimate for all the Type 2 and 1 rearing habitat surveyed in the Cat Arm system. The purpose of this is to obtain numbers which put the value of the total fish resource into some perspective. In interpreting these estimates, there are many conditions that must be noted. Firstly, the sampling sites were mostly in type 2 habitat, and these were, by definition, good salmonid rearing habitat. The mean estimates for Type 2 habitat were also applied to Type 1 habitat and this would tend to over-estimate total standing stock. Sampling sites **were not** randomly selected, due to the necessity to choose stations amenable to electrofishing. Extrapolation of estimates from these ideal sites to the total habitat in the rivers and streams, particularly in the lower Cat Arm River, tend to overestimate numbers.

Offsetting these considerations are several factors which tend to produce an underestimate (Beak 1980). Estimates of standing stocks in Type 3 and Type 4 habitat (and lakes or ponds) were not added to the overall standing stock totals. Habitat area was calculated using only the major tributary systems, and do not include the smaller tributaries. Late fall sampling could also possibly have lead to underestimates as trout may have been starting to drop back from the stream habitat to the the Type 4 habitat for overwintering.

Nevertheless, within the limits imposed by the above factors it is felt that a reasonable estimate of fish populations has been obtained for the tributary system in the Development area.

Standing stock estimates for the Cat Arm River below the lake were particularly hard to obtain. In flood conditions, sampling was limited to only one small tributary (S-2') one flooded site channel (S-3) and hence the estimates for this stretch of the Cat Arm River are unreliable.

A mark and recapture netting program with supplemental angling was used as the basis for estimating the population of salmonids in the pool below the barrier falls on the lower Cat Arm River. The total number of fish caught, not including recaptures, can be considered as the minimum standing stock of fish using the pool. This included 96 sea trout, 15 freshwater trout and 6 Atlantic salmon. Estimates of population size as shown in Table are in the order of 200 - 400 trout (greater than 150 mm in length) of which the majority are sea-run fish.

A total of 6 Atlantic salmon, 3 adults and 3 juveniles were netted during the course of this study from the pool, and a further 2 0+ salmon were electrofished from the stream habitat. Because of the very few salmon taken, no population estimates are available from the data. There is evidence however of a residual run of salmon in this river as four age classes are represented in our sample. This population is however likely very fragile due to the size of the population and the limits of the available habitat. Poor reproductive success over a period of a few years could severely set back or even eliminate salmon production in this river.

As a result of the few salmon taken during the survey little information has been added to the knowledge of the species in this section of the Cat Arm River. The best approach to take in evaluating the value of the lower Cat Arm River for Atlantic salmon is to estimate the potential for production of salmon from the survival and exploitation rates used by Fisheries and Oceans. This method applies smolt production rates per unit of habitat to the available habitat to yield a value for freshwater production of salmon. The sea survival rate (smolts to returning adults) is then applied to yield a value for the return adult run from the sea. Exploitation applied against this return run to determine the number of adult fish that are harvested prior to the fish reaching their spawning grounds. The values that we have applied are as follows:

Smolt production/unit habitat - 2 smolts/100 m^2
Sea survival rate - 11.8%
Commercial exploitation - 85% large salmon
- 55% 1 sea winter salmon
Angler utilization - assumed to be 0% for this river
% large salmon in population - 3%
Male/Female ratio - 1:2
Egg deposition to obtain maximum production - 150 eggs/100 m^2

It should be noted that these values are generalizations based on biological data obtained for specific production areas in Newfoundland, in this case for Production Area A. Only the broadest useage is intended for these values and individual stock management should be based on more site specific data. The approach we have taken is essentially a refinement of the methods used in estimating salmon production in the first report, but with more region specific survival and exploitation rates and a more precise quantification of habitat.

The total number of units of accessable rearing habitat (Type 1 and Type 2) available for salmon production is 43.6 units for the left hand channel (Type 2) and 116.5 units (12.8 units Type 1 and 103.7 units Type 2) for the right hand channel. The potential annual smolt production therefore is in the order of 320 fish. Applying the sea survival rate (11.8%) there would be an annual adult run of 38 fish "returning from the sea". Assuming a commercial exploitation rate of 55% (for 1 sea winter salmon) the total spawning escapement would be in the order of 17 fish (with 21 fish harvested by the fishery).

The required egg deposition to meet an annual production of 2 smolts per 100 m^2 has been determined to be 150 eggs per 100 m^2 for this production area. Therefore the required egg deposition to meet maximum production for this stretch of the river is 24,000 eggs. The three adult salmon netted during the survey were small grilse (1 sea winter salmon) averaging about 1.46 kilograms. Assuming an average fecundity of about 1540 eggs to the kilogram, it would require an annual run of 10 - 11 female grilse (of the size we netted, to the river to maintain maximum production. Also assuming a male:female ratio of 1:2 the total run of fish into the river to maintain maximum productivity would be in the order of 15 - 17 fish. Comparing this value with the potential adult production based on habitat, it is apparent the river theoretically could sustain a harvest of about 55% (including commercial, recreational and poaching) without affecting maximum productivity.

It is likely that the river is currently under producing salmon at present. The poor success in sampling juveniles appears to indicate very low juvenile density in the productive freshwater habitat, much less than would be required to produce the annual quota at 320 smolt.

Possible reasons for the river underproducing salmon include:

1. a low sea survival rate over one or several years (as experienced generally in Atlantic Canada over the sea winter of 1978 - 1979).

2. a higher rate of commercial exploitation.

3. poor freshwater production.

It is unlikely, because of poor accessability to the river, that recreational angling or poaching would be a significant factor affecting spawning escapement. Poor freshwater production may be related to low discharges experienced in the summer (115-13.3 m/s, July to September) and winter (6-7 m/s, January to March). In periods of low discharge more of the available water may be shunted into the left hand channel, the poorer of the two for fish production (see Habitat section). The result may be high mortalities of juveniles or large egg losses in the right hand channel. As the (potential) population of salmon in this river is small the ability of the population to respond to poor reproductive success over one or several years is low. Many of these factors, along with others, may be acting to maintain the population at "chronically" low levels.

It is also possible that juveniles were not detected because they also were in the estuary, and that the bulk of the adult run in this river may not have taken place at the time of sampling. The peak run in neighbouring rivers (Main River and Coney Arm River) takes place in early July (Porter 1975).

Lake Populations

The summary of gillnet catches for seven lakes in the future reservoir and forebay areas are presented in Table 11. Catches were extremely low, ranging from 1 to 36 fish per set and averaging 8.1 per set. These low catches are thought to be a result of declining temperatures ($7^{\circ}C$) in the lakes. With declining temperatures, fish metabolism and mobility are reduced. Since gillnetting is a passive sampling technique dependent on the movement of trout,

Table 11

Catch and biomass data for brook trout sampled by gillnet from 7 lakes in the Cat Arm watershed

Lake	Catch (nos.)	biomass (g)
Lake No. 1	36	4078.0
Lake No. 2	7	303.0
Lake No. 3	8	241.0
Lake No. 4	3	442.0
Lake No. 5	4	321.0
Cat Arm Lake	8	342.0
	9	316.0
	1	50.0
	13	511.0
	0	0.0
	6	310.0
	15	1066.0
	2	29.0
	4	339.2
Lake No. 7	6	609.0
Cat Arm Lake	22	289.6
	3	31.4

SOURCE: Beak, 1980

reduced mobility can influence the number catch Thus these gillnet catches should probably not be compared to catches taken during the summer.

In 1975, an overnight set of 3 nets made in Cat Arm Lake (L6) during August yielded 57 trout, all taken in the 3.8 cm mesh (Airphoto/Beak 1976). From this limited survey it was concluded that the abundance of trout in the lakes was relatively high. The largest catch in 1979 was made in Lake 1 (Figure 16) and these fish were relatively larger than the fish taken in the other lakes. These facts plus several other observations suggested that the trout had been caught while spawning on a shoal in the lake. There was a high proportion of sexually mature fish in this group; some fish were freshly spent while others were loose and runny; and some stomachs contained eggs. Most of the fish were taken within a small section of net. The observations from this lake support the hypothesis that lake spawning may be significant in these semi-isolated populations.

Some electrofishing was conducted along the shoreline of Cat Arm Lake (L6) and the presence of juvenile trout (0+ to 2+ age) was confirmed in the lake proper. Abundance could not be quantified but the catch per unit effort was similar to that from the streams.

No direct estimate of lake dwellings populations was obtained, however Airphoto/Beak, (1976) suggested that the estimates of standing stock and productivity calculated for Matamek Lake by Saunders and Power (1970) would be representative of the Cat Arm Lake population. Estimates of brook trout standing stock for Matamek Lake were 50 fish per ha (3.1 kg/ha). These estimates applied to Cat Arm Lake (112 ha) suggest a total standing stock of 5600 trout (350 kg). Applied to the total area of lakes in the reservoir zone, (11.4 km^2) they would suggest a standing stock of about 10 times that of Cat Arm Lake.

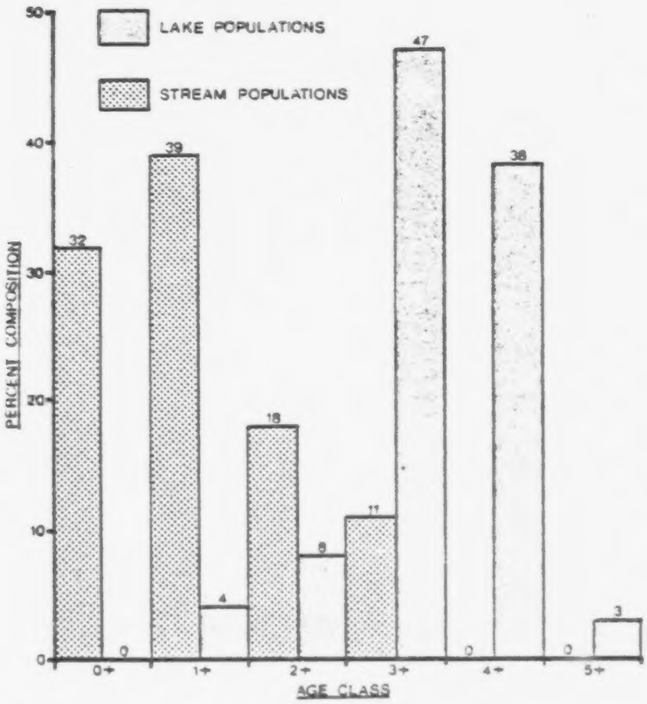
Age and Growth

The age compositions of brook trout in the lake and Type 2 stream habitat for the Cat Arm watershed are presented in Figure 19. In the stream populations there is a decline in percent composition by age class with increasing age. This decline in percent composition reflects both natural mortality and recruitment of trout to the lake environment and other stream habitats (Type 4) as they grow. The composition by age class of the lake environment reflects this recruitment to the lake habitat, likely

FIGURE 19

PERCENT OF EACH AGE CLASS IN TOTAL CATCH FOR LAKE AND STREAM POPULATIONS OF BROOK TROUT FROM THE CAT ARM WATERSHED, SEPT. 26 – OCT. 1, 1979.

* DOES NOT INCLUDE FISH ELECTROFISHED FROM THE SHORES OF CAT ARM LAKE.

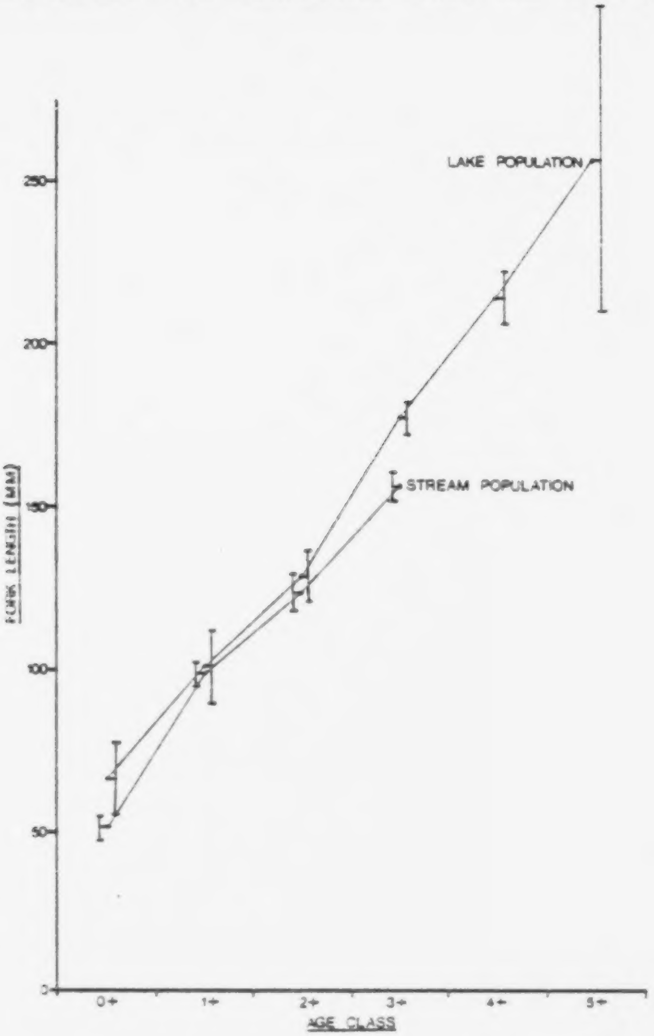


SOURCE: Beak, 1980

at the ages of 2+ and 3+. All age classes are represented in the lake population and the gillnetting survey did indeed indicate that the trout probably reproduce in the lakes. If it is assumed that all recruitment to the lake habitat occurs at or before the age of 3+, any changes in % composition of age classes 3+, 4+ and 5+ must, for the most part, reflect natural mortalities. It is apparent that there must be a high rate of mortality between the ages of 4+ and 5 +. Five year old fish were the oldest fish sampled and comprised only 3.0% of the total gillnet catch.

Wiseman (1969) has stated that there are three types of factors that influence growth rates - 1) genetic, 2) physiological, and 3) environmental.

FIGURE 20
GROWTH RATES (FORK LENGTH VS. AGE) FOR STREAM AND LAKE POPULATIONS OF BROOK TROUT FROM THE CAT ARM WATERSHED. 95% CONFIDENCE UNITS ARE ALSO INCLUDED.



SOURCE: Beak, 1980

In general, it is difficult to distinguish genetic and physiological factors on the basis of field sampling. On the other hand, influence of environment on growth is more obvious and interpretations are more valid. Such environmental influences can often mask genetic variation.

Growth rates of lake dwelling brook trout in the Cat Arm watershed appear to be slightly faster than the rate of growth of stream populations (Figure 20). As both populations are from similar genetic stock, the genetic and physiological make up of the populations should be similar.

Scott and Crossman (1973) have suggested a general situation for trout growth stating that there is a direct relationship between rate of growth and habitat area, with a steady increase in rate of growth from stream to pond to lake. In the context of the Cat Arm watershed this relationship appears to hold true. Growth seems to be faster in the lake populations at the age of 2+ and 3+. Trout in Hinds Lake (Beak, 1977) and at Matamek Lake (Saunders and Power 1970) show a similar increase in rate of growth reflecting a change in habitat.

Food availability and quality is a major component in determining rate of growth. Several authors have postulated that the unavailability of larger food items limits the size and growth of trout in many waters in Newfoundland. At Hinds Lake, Beak (1977) found that there was a noticable increase in rate of growth when trout change from a mainly piscivorous diet.

The availability of benthic (littoral) invertebrates is presently an important factor in trout growth at Cat Arm. As the dominant food source of both lake and stream populations, invertebrate production in the future Cat Arm watershed will continue to play an important role in the success of the fisheries resources. The method of reservoir operation and its impact on littoral invertebrate production would in turn, affect fish growth.

Sex and Maturity

In the 1979 study, stream populations of brook trout showed no significant deviation from the expected 1:1 sex ratio (Table 12). Of the 124 fish sampled for sex from all streams, 59 were male and 65 were female, for a male: female sex ratio of 0.92:1. Other authors (Wiseman, 1969; Wheeler, 1977; Bruce, 1974; Parsons, 1975) have reported no significant differences between numbers of males and females in the populations that they studied.

There was, however, a significant departure from the normal 1:1 sex ratio in the brook trout sampled from all the lakes. Of the 138 fish sampled for sex, 96 were male and 42 were female for a male:female sex ratio of 2.29:1. This male dominated sex ratio is most evident in the 2+ (male-female ratio 2.45:1, 3+ (male-female ratio of 4.00:1) and 4+ (male-female ratio of 1.86:1) age groups. There may be several explanations for this deviation from expected sex ratios. Firstly, there may have been some bias in sampling. The sampling period coincided with the spawning season of trout and female brook trout may not be as active as male members of the population at this time of year. Females may be

Table 12

Sex ratios for each age class of lake and stream populations of brook trout sampled from the Cat Arm watershed

Age Class	No. of fish sampled for sex	No. of males	% males	No. of females	% females	Sex ratio (male:female)
			STREAM POPULATION			
0+	-	-	-	-	-	-
1+	47	21	45	26	55	0.82:1
2+	52	23	41	29	59	0.69:1
3+	25	15	60	10	40	1.50:1
Total	124	59	48	65	52	0.92:1 $X^2_{(1)}=0.29$
			LAKE POPULATION			
0+	-	-	-	-	-	-
1+	13	6	46	7	54	0.85:1
2+	17	12	71	5	29	2.45:1
3+	56	45	80	11	20	4.00:1
4+	48	31	65	17	35	1.86:1
5+	4	2	50	2	50	1:1
Total	138	96	70	42	30	2.29:1 $X^2_{(1)}=21.12$

$X^2_{(1)}$=chi-squared test for deviation from an expected 1:1 sex ratio.

SOURCE: Beak, 1980

holding to restricted reproductive sites in the lakes and most of our nets may not have been set near these areas. Gillnetting is a passive sampling technique and its success is dependent on mobility of the target species.

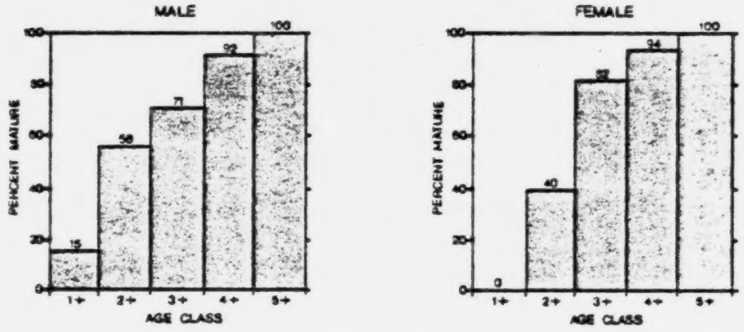
A representative sample of fish was sampled for sex from the Cat Arm Lake gillnet catch in the August 1975 study period. This same trend in sex ratios (a male-female ratio of 1.95:1) was evident during that sampling period which did not overlap the reproductive season. There is evidence then, that some other mechanism may be operating to produce this male dominant population.

There is a possibility that some selective mechanism is causing a high rate of mortality in the females of the population. Upon examining the sex ratios of different age groups, it appears that this mortality may be related to maturation and/or recruitment to the lake habitat. It is possible there may be a genetic adaptation to limitations in the environment to reduce overall reproductive success.

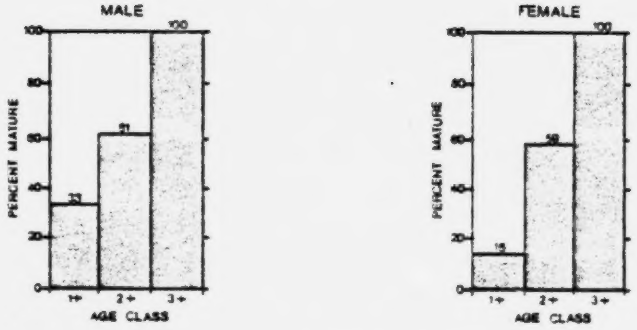
Figure 21 present the maturity data for lake and stream populations of brook trout for each sex. The majority of the fish reach maturity at the ages of 2+ and 3+. In stream population, 100% of the fish were mature at the age of 3+, while in the lake populations 76% were mature at this age. Other authors have reported that the majority of brook trout mature between the ages of 2+ and 3+ (Wheeler, 1977; Bruce, 1975; Wiseman, 1969, Wydoski and Cooper, 1966). In the lake populations 100% maturity is not reached until the age of 5+, while a significant number of the population was

FIGURE 21

COMPARISON OF AGE, SEX, AND MATURITY BETWEEN LAKE AND STREAM POPULATIONS OF BROOK TROUT SAMPLED FROM THE CAT ARM WATERSHED. SEPT. 26 – OCT. 1, 1979.



LAKE POPULATIONS



STREAM POPULATIONS

mature at the age 1+. Wydoski and Cooper (1966) have reported that trout are inherently capable of maturity at the end of their first year of life.

Males were found to be maturing at an earlier age (33% of the stream populations mature at 1+) than females (15% mature at the age of 1+). This is also evident in the lake population. Wiseman (1969) has also reported a trend towards early maturation of males in his study of trout populations in insular Newfoundland. He reported that, generally, 50% of all males were mature at the age of 2+ while 50% maturity in females was only reached at age 3+. He also noted that males generally mature at a smaller size than do females.

The fecundity of the population was not examined in detail. One mature female (2+, 131 mm) contained only 18 eggs. In all fish populations there exists a direct relationship between size of females and the number of eggs produced. Wiseman has reported that, in the populations of trout he studied in insular Newfoundland, fecundity was roughly proportional to cube of length of the fish.

Mature, ripe and spent fish were sampled from both habitats. There is evidence that spawning is occurring in both the stream and lake habitats. The gillnet catch in Lake 1 took 36 fish (by far the largest 1979 gillnet catch) all similar in size, and most were ripe or spent. Twenty-one of these fish were at the bottom of the net within a section 1.5 m in length. There is good likelihood that this gillnet catch reflected a spawning aggregation in the lake. This suggests that recruitment is not strictly a stream-to-lake occurrence in the Cat Arm system. More likely, a range of situations prevail in which some lakes are practically self-sustaining, recruitment to others is from both the lake and stream system, while some lakes may rely exclusively on escapement from streams as their source of recruitment. Conversely, some of the headwater tributaries may contain self-sustaining populations.

Stomach Analyses

During the September-October 1979 study period, brook trout from the river systems and the lake habitats were analysed for stomach contents and fullness (Table 13). Trout were found to be feeding primarily on insects. Benthic organisms were more readily utilized than other (pelagic and terrestrial) insect groups. Unidentified zooplankton were also found in the stomachs of several fish sampled from Cat Arm Lake. There is good likelihood that this zooplankton is *Daphnia catawba*, the most abundant species taken in zooplankton samples in August, 1975 from Cat Arm Lake.

Wheeler (1977), Bruce (1974) and Beak (1979) have also reported benthic invertebrates to be the dominant or exclusive food source of trout sampled from similar habitats in Labrador. Wiseman (1969) has reported that the brook trout diet in insular Newfoundland consists of terrestrial and aquatic insects, other invertebrates, and forage fish. Other studies have reported piscivorous feeding habits in older brook trout in insular Newfoundland when forage is available (Beak, 1978 and 1979).

Two aspects of cannibalism were found in brook trout sampled from lake habitats of the Cat Arm watershed. Brook trout eggs were the third most common food item found in the stomachs of fish sampled from the lakes. Three occurrences of trout remains in the stomach of lake dwelling brook trout were also found. Scott and Crossman (1973) have reported that brook trout engage in a limited amount of cannibalism,

Table 13

Qualitative Stomach Analyses of Brook Trout
Sampled from the Cat Arm Watershed,
Sept 26-Oct. 1, 1979

	Stream Fish	Lake Fish
No. of fish examined	31	130
Stomach fullness, %		
full	39	18
3/4	0	4
1/2	16	9
1/4	10	25
empty	35	45
Stomach contents, % occurrence		
damselfly nymphs	3.2	6.9
caddisfly larvae	22.6	16.9
dragonfly nymphs	0	4.6
coleoptera	0	2.3
terrestrial insects	0	1.5
tipulidae	6.5	0
corisidae	6.5	0.8
littoral crustaceans (unidentified)	0	2.3
unidentified insect parts	25.8	23.8
unidentified zooplankton	0	0.6
brook trout eggs	0	12.3
brook trout remains	0	4

SOURCE: Beak, 1980

and that eating their own eggs during the spawning period is not uncommon. This is a seasonal variation in the diet of trout and this aspect of cannibalism points out the opportunistic nature of trout feeding habits.

The fact that trout remains were found in the stomachs of three fish is more significant. Scott and Crossman (1973) have reported that trout can eat their own young in the spring. The incidences of cannibalism found in this study, although not extensive, did involve the ingestion of juvenile trout 1+ and 2+ in age.

Cannibalism was also prevalent in trout sampled from the Hinds Lake area, (Beak, 1978) with small (80-120 mm) trout being fed upon by older larger trout. In this situation cannibalism accompanies other piscivorous feeding habits, and trout are effectively occupying two trophic levels in the food chain. The result of this diet is a sizeable population of relatively large trout representing a potential sports fishery resource.

In the Cat Arm situation there is no significant population of large trout. Cannibalism, in this instance, is likely a result of a lack of forage species and the need to supplement the available diet of littoral crustaceans and insects. Other authors have reported that cannibalism is rare and probably only occurs when food is scarce (Scott and Crossman 1964). Cannibalism may be an indicator of poor feeding condition and limited food supplies. From a bioenergetic point of view, the energy input from the available diet may be sufficient for growth and body maintenance in the younger age classes of trout. As trout grow their energy needs also increase. The available diet may be deficient in quality and quantity in meeting the energy needs for body maintenance, growth, and food foraging in the older age classes.

A number of trout were found with empty stomachs (35% of stream fish and 45% of lake fish) in 1979. In the 1975 sample the average volume of food per stomach was low and many stomachs were also empty. This is not an uncommon occurrence in such trout populations. The low water temperatures (and corresponding low body metabolism) may have been reflected in the analysis of stomach fullness of fish sampled in 1979. Similarily many fish species do not feed or feed sparingly during the reproductive season. Wiseman, 1969 has noted that several authors have reported a reduction or cessation of feeding during the spawning season.

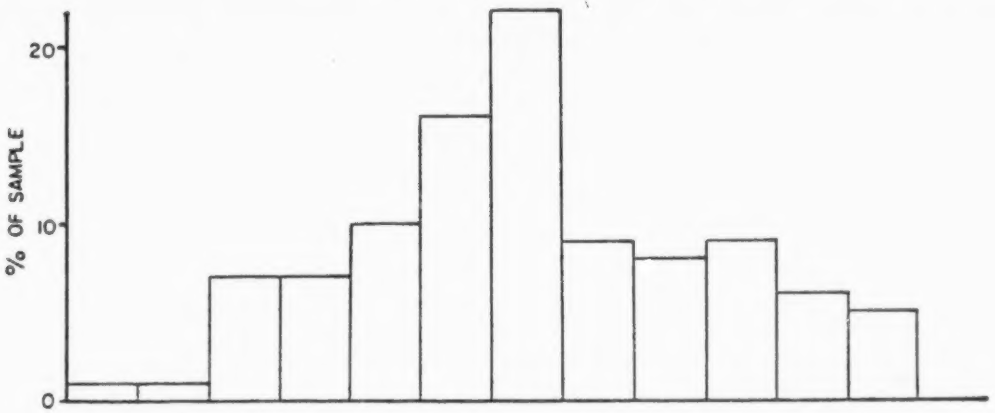
Two salmonid species found in the lower Cat Arm River are the species that receive the brunt of the angling pressure in the province of Newfoundland. The potential sports fishery for these species is however limited and the value of the resource must be put into perspective.

The sports fish resource in the study area revolves around the anadromous trout and Atlantic salmon population. The sea trout are a potentially more desirable sports fish than the freshwater variety. Figure 22 compares the size distribution of both

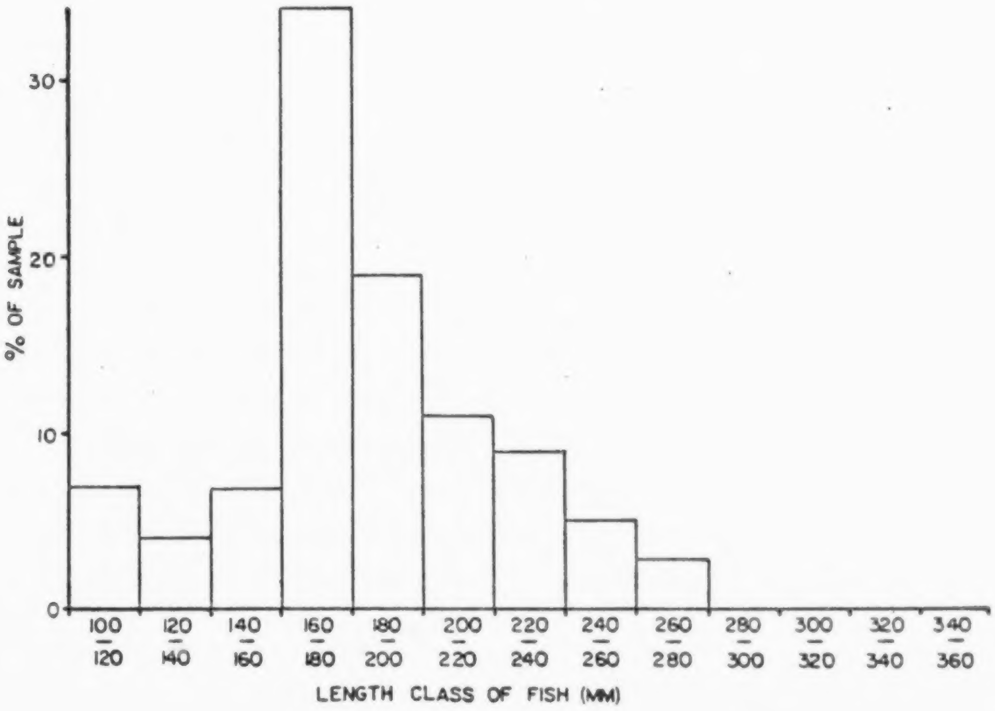
FIGURE 22

LENGTH-FREQUENCY DISTRIBUTION OF ANADRAMOUS AND FRESHWATER BROOK TROUT SAMPLED FROM THE CAT ARM WATERSHED.

ANADRAMOUS BROOK TROUT SAMPLED BY LIVE TRAPPING AND GILL NET FROM THE POOL BELOW THE BARRIER FALLS ON THE LOWER CAT ARM RIVER AND FROM THE ESTUARY (n = 88)



FRESHWATER BROOK TROUT SAMPLED BY GILL NET FROM SEVEN LAKES ON THE CAT ARM PLATEAU (n = 122)



populations and it is apparent the sea trout grow larger, and that the larger fish (in excess of 250 mm - 10 inches) form a sizeable portion of the population. Sea trout are also preferred to freshwater trout by most anglers because the sportsmen perceive that all sea trout have pink-orange flesh which they equate with better flavour. The population is however small and restricted by the available habitat. Also because of the migratory nature of the sea trout, the availability of fish to a recreational fishery will mostly be limited to their freshwater residency, although some anglers do fish for sea trout in salt water, usually at freshwater influxes. In short this population does represent potential for a small, seasonal sports fishery.

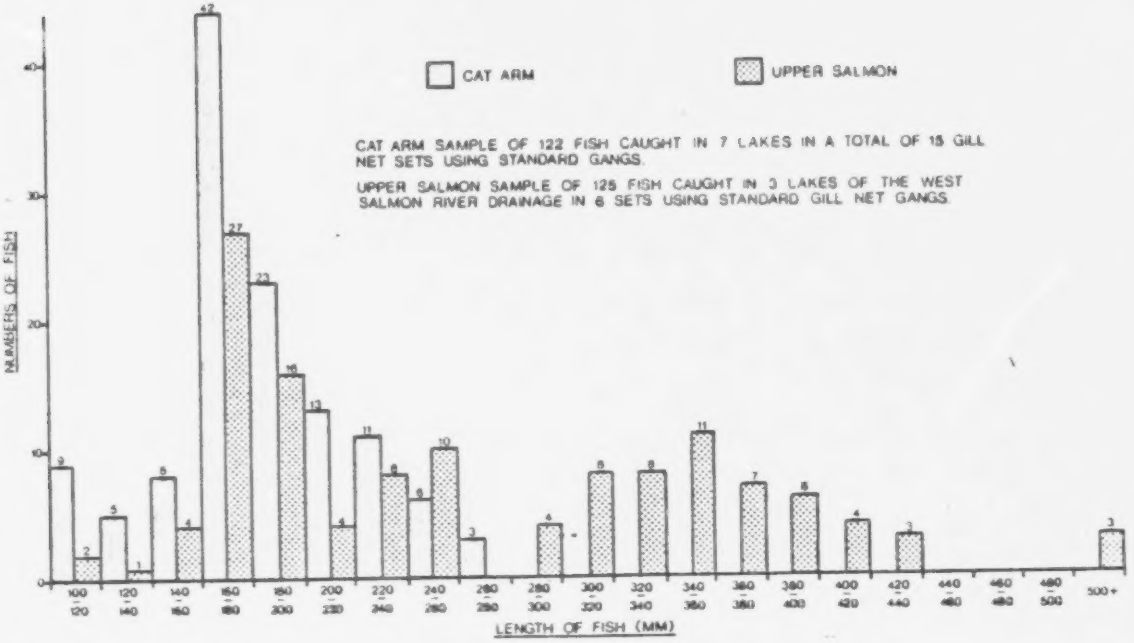
The potential for harvesting Atlantic salmon from this river has been derived from estimates of production based on habitat. Allowing for a spawning escapement to maintain maximum production there is a potential availability of 21 fish (grilse size) to either a commercial and/or recreational fishery at present. This potential will further be reduced after impoundment of the Cat Arm River. In the last record of angling effort on the Cat Arm River (1965), 17 angler days were expanded with a net yield of 5 grilse size salmon (Porter, 1974). It is apparent there is very limited opportunity for salmon angling in this river.

In addition to the small size of the salmonid population available to angling, the remoteness of the lower Cat Arm River is also going to deter most fishermen. Access at present is only by boat, floatplane, or helicopter - all expensive means of travel. Access in the future, after development, will not be improved as access roads are going to avoid the Cat Arm estuary area. If access were to be provided, the resource could not handle much angling pressure and it is likely anglers would crop most of the residual population.

Resident trout populations can be characterized as abundant, slow growing, small and shortlived. The maximum size trout taken from the study area was 257 mm (10 inches) in length. The average size of trout taken in the gillnet catch was 184 mm (7 inches). Neither is there any obvious strategy available which would result in the potential to produce trophy sized fish. To put the size of trout in the study area lakes into perspective, a comparision of the length distribution of trout at Cat Arm and Upper Salmon is made in Figure 23.

Access to the Development area is at present very restricted. Access to the headwater ponds is possible by helicopter and by float plane to a couple of the large ponds. The river below Cat Arm Lake is accessible only by helicopter. The river itself is difficult to traverse due to the large number of falls and rapids. The stretch of river below the falls at the mouth of Cat Arm River is accessible by boat from the Great Cat Arm. If freer access were to be provided, the resource could not handle much angling pressure and it is likely anglers would crop most of the residual population. At present the only means of access to the watershed are expensive, and in fact prohibitive in view of the sports fishery value of the resource.

FIGURE 23
LENGTH – FREQUENCY DISTRIBUTION FOR BROOK TROUT SAMPLED BY GILL NET FROM CAT ARM WATERSHED AND THE UPPER SALMON WATERSHED.



CAT ARM SAMPLE OF 122 FISH CAUGHT IN 7 LAKES IN A TOTAL OF 15 GILL NET SETS USING STANDARD GANGS.

UPPER SALMON SAMPLE OF 125 FISH CAUGHT IN 3 LAKES OF THE WEST SALMON RIVER DRAINAGE IN 6 SETS USING STANDARD GILL NET GANGS.

SOURCE: Beak, 1980

The watershed is distant from the two nearest population centres. Cat Arm Lake is 45 air miles from the float plane base at Pasadena, near both Corner Brook and Deer Lake. When road access to the watershed is available, after development, the angling resource at Cat Arm would have to be attractive enough to have people drive the distance to the future reservoir. The Cat Arm resource would further have to be attractive in view of the high quality salmon and trout fishing opportunities presently available in the area.

The cost of access, the small size of the resident sport fish, and the availability of alternative sport fishing opportunities limits the potential angler use of this region. At present the only angler use is by people who are in the area for other reasons, specifically big game hunters. There is no commercial fishery for sea trout in the area nor have any local fishermen interviewed ever caught sea trout as an incidental catch.

3.2.6 Terrestrial Vegetation

A preliminary examination of vegetation types was conducted by Airphoto/Beak (1976). This work was further elaborated by Slaney (1978) and Hunter (1980). The more recent work concentrated on those areas of the Cat Arm watershed specifically impacted by the proposed Development, i.e., the reservoir flood zone and sites of major civil works (eg. dams, powerhouse, construction camp). The following sections describe in a generalized manner the vegetation types found in the proposed Development area. The classification system is based on the Hunter (1980) work. Detailed maps and tables of study quadrats can be found in Airphoto/Beak (1976), Slaney (1978) and Hunter (1980).

A. Woodland

These are communities of plants associated with trees producing 30% to 60% canopy cover. Woodland tree canopies are broken with a tall scrub strata (1 m - 5 m high) giving total woody cover of at least 50% or more. At Cat Arm, Balsam Fir (Abies balsamea) predominates, frequently with Black Spruce (Picea mariana) secondary or co-dominant. Data indicates that Black Spruce dominates only about 20% of the area Woodlands. White Birch (Betula papyrifera) occurs in very low numbers, but is widely scattered and occurred in 40% of the samples. A small area on the west central margin of the proposed reservoir was airphoto interpreted to be Birch dominated, but was not observed or documented in the field. White Spruce (Picea glauca) is very uncommon, and was seen only once. Field estimates of total tree canopy cover varied 19% (39%) - 45%.[1]

The sapling regeneration usually reflected tree canopy composition, and the major tall scrub species were, as expected, Balsam Fir and Black Spruce saplings. In this strata, Black Spruce was prevalent in only 13% of the sample sites, Black Spruce co-dominant in 40% of the sites, and in the remainder Balsam Fir was a strong dominant. Saplings produced 14% (34%) 65% cover. Other species in this strata were incidental in occurrence. Further details on woody vegetation are given in the Tree Inventory Section and Table 14.

[1] This numerical sequence used throughout this section of the report corresponds to low (average) high values of estimated total tree canopy cover.

Dwarf shrubs (below 1 m high) are rich in the Cat Arm Woodlands, with at least 14 species documented giving 28% (50%) 70% cover. Major species include Balsam Fir and Black Spruce seedlings, with populations of the Tall Huckleberry (Vaccinium ovalifolium), Twinflower and Creeping Wintergreen (Linnea borealis and Gaultheria hispidula). Bake apple (Rubus chamaemorous), Blueberries and Partridge berries (Vaccinium angustifolium and V. vitis-idaea) were less abundant but widespread.

Grasses and herbs include over 20 species that provide 11% (35%) 60% cover. The most consistently important and widespread species were Goldthread and Bunchberry (Coptis gorenlandica and Cornus canadensis), with Three- seed Sedge (carex trisperma) less frequently important. Species widespread, but with low cover values included Bluebead Lily (Clintonia borealis), Wood Fern (Dryopteris spinulosa), Large-leaved Goldenrod (Solidaga macrophylla) and Starflower (Trientalis borealis).

Mosses were very important in these woodlands, with 55% (82%)-100% cover. Pleurozium schreberi was common to abundant throughout, often in association with Sphagnum spp. and Feather-mosses (i.e. Ptilium cirsta-castrensis and Hylocomium splendens). Lichens on the ground were far less important, with 0% (8%) 20% cover. Major lichen species were Peltigera aphtosa and P. spuria, with many species of the "cup" Cladonias. On the other hand, 60% of sites visited had a heavy to very heavy strata of epiphytic lichens indicating the humid local climate of the reservoir area.

B. Scrub

These are communities of plants associated with shrubs or obviously repressed trees less than 5 m high, less than 10 cm (4 in) diameter at breast height (DBH) and yielding 30% or more canopy cover.

In the Cat Arm reservoir area, Scrub is predominantly repressed Black Spruce and Balsam Fir on better drained sites, with Lambkill (*Kalmia angustifolia*), Creeping Winterberry and Labrador Tea (*Ledum groenlandicum*). Wetter sites have dwarfed Larch (*Larix laricina*) added, with Leathleaf (*Chamaedaphne calyculata*) and *Phyllodoce caerulea* important. Lambkill is replaced, at lower cover values, by Bog Laurel (*Kalmia polifolia*) on these sites. Scrub showed complete gradation from tall (5 m) to dwarf stature (below 1 m). Woody cover ranged 25% (61%) 100%, with gradations to lower cover and stature relating to transitions from Scrub to Bog and/or Tundra-Barren.

Grasses and herbs were sparse, with 5% (19%) 43% cover, provided by about 16 species. Plants frequent in Woodland also occurred in the Scrub communities on better drained sites. Wet Scrub showed affinities with Bog, with the sedges *Carex oligosperma* and *Scirpus caespitosus* most common.

Moss cover was very variable, with 15% (56%) 100% cover. Low cover values related to lichen rich Tundra-Barren scrub and moss-poor Wetland Scrub.

These respectively had *Rhacomitrium* and *Sphagnum*, while dry and wet Scrub had *Pleurozium schreberi* and *Spaghnum* spp. prevalent respectively.

The most important lichen strata had from 30% to 50% cover with *Cladonia rangiferina*, *C. mitis* and *C. alpestris* and were associated with the Tundra-Barren transitions. Lichens were incidental in occurrence elsewhere, except for infrequent heavy epiphytes.

C. *Riparian*

Woody plant communities along flowing streams (as well as lake-shores) showed consistently increased shrub cover, usually with reduced or more broken tree growth. The major Woodland Tree species usually occurred, with increased numbers of Larch. Dwarf Birch (*Betula glandulosa*) and Sweet Gale (*Myrica gale*) were important shrubs. Grasses and herbs were usually important, with *Aster puniceus*, *Calamagrostis canadensis*, *Carex oligosperma*, *C. gracillima* and *Sanguisorba canadensis* frequent and producing about 30% to 70% cover. Mosses were less frequent, the most notable species observed being *Polytrichum juniperinum* and lichens are incidental.

The more youthful marsh communities were dominated by open water and an abundance of such species as *Carex oligosperma*, *C. lasiocarpa*, *Juncus effusus*, *Scirpus atrocinctus*, *Iris versicolor* and *Myrica gale*.

Successional stages result in the buildup of organic material until it reaches or is slightly above the water table. These seral stages are often transitional to fen development. Common species include *Sanguisorba canadesis*, *Aster nemoralis*, *Chamaedaphne calyculata*, *Carex echinata*, *Carex limosa*, *Aster novibelgii*, *Potentialla palustris*, *Smilacina trifolia*, *Drepanocladus revolvens*, *Geocaulon lividum* and *Sphagnum robustum*.

D. *Wetlands (Bogs and Fens); Tundra-Barrens*

Communities were observed to be typical of Boreal and Subarctic environments in eastern Canada, with low (1 dm - 5 dm) more or less continuous cover. The poorly drained depressions are characterized by small, shallow (1 m) sedge bogs. Morphologically, these bogs consist of partially decomposed mesic sedge *Sphagnum* peat over a compacted humic layer of sedge peat extended to a lithic contact. *Sphagnum* mosses (e.g. *S. papillosum*, *S. magellanicum*, *S. subnitens*) and sedges (*scirpus cespitosus*, *Carex oligosperma*, *C. exilis*) were abundant. Dwarf shrubs were common.

The patterned fens are generally sloping and shallow (100 cm) organic deposits characterized by surface patterning which is oriented at right angles to the direction of slope. The underlying peat consists mainly of decomposed to partially decomposed compacted sedges and, to a lesser extent, *Sphagnum* mosses. This peatland type occurred most extensively throughout the western and northwestern sections of the watershed.

Sedges, grasses and herbs were abundant and include *Carex oligosperma*, *C. limosa*, *C. michauxiana*, *C. exilis*, *Eriophorum spissum*, *E. virginicum*, *Scirpus* *cespitosus* and *Calamagrostis inexpansa*. *Sphagnum* mosses (e.g. *S. strictum*, *S. compactum* and *S. paillosum*) were also frequent.

Most of the plant species which comprise this rock heath are adapted to environmental extremes such as dessication and snow abrasion from high winds, low temperatures, and freeze-thaw cycles. These adaptations include growth forms such as dense prostrate mats (e.g. *Empetrum nigrum*), cushions (e.g. *Loiseluria procumbens*, *Rhacomitrium lanuginosum*) and dense tussocks (e.g. *Potentilla tridentata*). Other plants commonly occurring in this tundra-like environment include *Vaccinium uliginosum*, *Arctostaphylos uva-ursi*, *Cetraria nivalis* and *Juniperus communis*.

In summary, the Cat Arm watershed is relatively well vegetated with Fir-Spruce Woodland, Scrub and Wetlands (mostly Bogs). True Forests do not occur. Woodlands occur in sheltered valleys and basins and consist of 35 percent of the proposed reservoir area. Scrub transitions occur between the Woodlands to the Wetlands, and also to Tundra-Barren communities or rock lands. Distinctive zones of vegetation occur along lakeshore and streams. A summary of the area dominated by each of these vegetation classes and by water within the proposed reservoir area is given in Table 14.

Table 14

VEGETATION AND WATER AREA TO BE FLOODED

Vegetation Class	Approximate Area* (ha)	%
Forest	---	---
Woodland	1,945	35
Scrub	1,167	21
Riparian	180	3
Wetland (Bog and Fen)	420	8
Tundra-Barren	597	11
Water	1,240	22
TOTAL ESTIMATED RESERVOIR AREA	5,549	100

*These areas calculated with 1300' FSL.

SOURCE: Hunter and Associates, 1980

3.2.7 Forest Resource

Bowaters' Newfoundland Ltd. hold the wood rights to most of the forest resource in the Development area. They estimate that their Lease Limit 368 contains about 532,000 solid cubic meters of wood (S. Weldon, pers. comm., 1980). However, this Lease Limit includes about four times the area of the proposed Development. Airphoto/Beak (1976) gave a conservative estimate of at least 40,000 cords of pulpwood in the reservoir zone, based on preliminary airphoto interpretation. Initial estimates of merchantable timber in the reservoir made by Slaney (1978), totaled 326,200 stacked cu m (90,000 cords). Slaney cautioned that inadequate data existed to reliably predict the volume of merchantable wood, and reported tree stand examples from nearby, but not within, the reservoir.

Hunter (1980) conducted a tree inventory based on 16 quadrat studies taken in conjunction with the vegetation field survey. Field data observed included tree, sapling and seedling counts, and low (minimum), average and high (maximum) values for stem height and diameter at breast height (DBH). Low, average and high values were applied respectively to 25%, 50% and 25% of the trees tallied for each quadrat in calculating total volumes reported in this study. Trees in the study area ranged from 69 (103) - 130 years old, and the average Forest Capability is Class 6 (1.7 cu m/ha/yr). Basic stand data is summarized in Table 15. Volume estimates were derived from Newfoundland Forestry Tables (Hutcheson and Kerr, 1978). Reservoir totals have been calculated using a Full Supply Level (FSL) elevation of 396 m (1300 ft) (Shawmont, 1977) and so are an over-estimate given the revised FSL of 393 m (1290 ft).

A. Productive and Merchantable Wood

All stems larger than 10 cm DBH and more than 5 m high, living and not obviously deformed are defined as productive wood. Final figures for the reservoir are summarized in Table 15. It is estimated that there are approximately 2,000,000 productive stems in the flood zone, giving a total volume of about 350,000 solid* cu m of wood. Of this, at least 220,000 cu m (91,000 cords) occurs in stands continuous or dense enough to be considered merchantable. Merchantable stands are defined as those yielding 60 cu m or more per hectare

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*A solid cubic metre is approximately 2/3 of a stacked cubic metre.

(at least 10 cords per acre or 90 stacked cu m per hectare).

Table 15

TREE, SAPLING AND SCRUB SUMMARIES, CAT ARM RESERVOIR, 1979

	Per Hectare	Approx. Reservoir Total
Trees		
Productive Stems (No.)	602 (1473) 2322	2,900,000
Productive Volume (Solid cu m)	631 (177) 392	350,000
Merchantable Volume (Solid cu m)		220,000
Sub-Merchantable Volume (Solid cu m)		130,000
Cull Stems (No.)	198 (721) 1940	1,400,000
Cull Volume (Solid cu m)	10 (52) 159	103,000
Saplings		
Total Sapling Stems (No.)	2100 (3928) 8281	6,500,000
Scrub		
Total Scrub Stems	8889 (11,320) 13,750	24,500,000

SOURCE: Hunter and Associates, 1980

B. Cull Wood

Heart rot cull determined from tree core samples indicate that 14% of otherwise productive standing trees can be considered cull wood. Counts and size estimates were also made of deformed trees, standing dead and fallen dead trees in the quadrats (Table 15). There are about 1,400,000 cull stems in the reservoir, or slightly more than 1 cull stem for every two productive stems that occur. These produce approximately 103,000 solid cu m or wood, or almost exactly 1/3 the total volume of productive timber.

C. Saplings and Scrub Stems

Quadrat counts of sapling and scrub stems of tree species (1 m - 5 m high) are summarized in Table 15. These suggest totals of about 8,255,000 sapling stems associated with Woodland and 13,210,000 shrub stems associated with Scrub communities.

3.2.8 Wildlife

The "Preliminary Upper Salmon/Cat Arm Environmental Impact Assessment" (Airphoto/Beak, 1976) included an assessment of the data available on the wildlife resources of the proposed Cat Arm Hydroelectric site. The lack of site-specific wildlife data and therefore the difficulty of impact assessment were noted in that report. It was recommended that further wildlife studies be undertaken prior to development to supplement existing baseline data. Acting on this recommendation, Newfoundland and Labrador Hydro conducted bird and mammal surveys in 1977, (Blacquiere, 1977, Slaney, 1979); a joint Hydro-Parks Canada-Provincial Wildlife caribou survey in 1979 and 1980 (Northlands, 1980), and directed its consultants to record incidental wildlife observations during their field programs (Hunter, 1980, Shawmont, 1980c).

The purpose of the terrestrial wildlife program was to establish which species of ungulates, small mammals, furbearers and birds use the Cat Arm River watershed and surrounding area. Sensitive areas such as moose yards, caribou calving areas or any unusual concentration of animals were to be located. General habitat conditions were to be described and any rare or unusual species noted. Surveys were conducted in July 1977, December 1977, April 1978 and October 1979 through June 1980. Methods included both aerial and ground transect surveys. The latter included browse surveys, pellet counts, track counts and habitat classification. The following sections summarize the results of the terrestrial wildlife program.

A. Birds

A small number and variety of aquatic birds were observed during the survey. In the proposed main reservoir a total of 38 waterfowl were recorded. These included Canada Goose, Black Ducks and Mergansers. A more complete list of avifauna species in the main reservoir is given in Appendix I.

All geese observed were adults in flocks in either the northwest branch (22 individuals) or southwest branch (10 individuals) of the reservoir and did not fly when approached by the helicopter. A single Merganser and five Herring Gulls were observed in the Cat Arm River downstream of the proposed dam site. No mating displays (probably too late in the year) or broods (probably too early) were observed.

The density of waterfowl (Table 16) in the proposed main reservoir area (0.92 birds/km^2) is high compared to results obtained by other workers. Gillespie and Roberts (1968) in the spring of 1968 surveyed an estimated 2380 km^2 of the island of Newfoundland by fixed wing aircraft and saw a total of 1451 waterfowl, or 0.61 birds/km^2. On a survey of Hinds

Lake on June 2 and 3, 1977 using methods similar to those employed at Cat Arm, Bruce Johnson (pers. comm.) reported 19 waterfowl in 85.5 km^2, or 0.2 birds/km^2. The higher density found in the Cat Arm survey is more likely attributable to the intensity of the survey rather than to any greater productive value of the area. The timing of the survey and nature of the habitats covered may have also influenced the results.

Table 16

List of birds observed during the July 12, 1977 helicopter waterfowl and raptor survey of the main reservoir area of the proposed Cat Arm hydroelectric project.

Species	Number Observed	Waterfowl Density[1] (birds/km^2)
Birds:		
Waterfowl		
Canada Goose (Branta Canadensis)	32	0.78
Black Duck (Anas rubripes)	4	0.10
Merganser species (Mergus spp.)	1	0.02
Unidentified Waterfowl	1	0.02
Total	38	0.92
Others		
Greater Yellowlegs (Tringa melanoleucus)	2	
Unidentified Sandpiper	1	
Herring Gull (Larus argentatus)	11	
Tern species (Sterna spp.)	2	
Tree Swallow (Iriodoprocene bicolor)	1	
Unidentified Passerine	6	
Total	23	

[1] (Density calculations of waterfowl are based on a coverage of 41 km^2.

SOURCE: Blacquiere, 1977

Ponds and islands are numerous throughout the proposed Cat Arm Development area but most are rock lined with little if any of the emergent vegetation which waterfowl require as cover. The surrounding conifer woodlands indicate the ponds have a high acidity which may restrict invertebrate populations (See Section 3.1.6) necessary for the growth of young ducks. These factors probably combine to severly limit waterfowl potential. The presence of geese may indicate that there is adequate grazing for them on the barren hilltops but undoubtedly food for young geese is limited.

Solitary adult bald eagles were sighted along both the Cat Arm and Coney Arm Rivers in October, 1979, (Shawmont, 1980). An eagle nest is usually occupied near Devil Cove, (pers. comm. J. Head). Ospreys are reported along the coast but none were sighted during field work. Large numbers of Herring gulls and Kittiwakes were regularly sighted along the coastline. Occasional Cormorants were also seen. Common Murres are hunted by residents of Jackson's Arm who also report sighting occasional Puffins and Razor-billed auks.

None of the birds were observed in breeding activities, but this could be a result of the nature and timing of the survey. The waterfowl in the area may be non-breeding individuals loafing there. This is particularly true of geese which often require three years to mature (Bellrose, 1976). Only the Herring Gull is known to nest, but Terns, Greater Yellowlegs, as well as a number of passerines, probably breed in the area.

There were no field surveys undertaken to determine spring and fall use with regard to migratory stop-off points or staging areas, since the Development area is not on any major migration routes. Most birds moving north or south would tend to move along the more productive west coast of Newfoundland.

B. Mammals

Data on mammal populations are detailed in Airphoto/Beak (1976), Slaney (1979) and Northland (1980). Table 17 lists mammal species likely to occur in the Cat Arm area.

Table 17

MAMMALS OF THE PROPOSED

CAT ARM DEVELOPMENT AREA

Common Name	Scientific Name
Masked shrew	Sorex cinereus
Little brown bat	Myotis lucifugus lucifugus
Keen's bat	Myotis keenii septentrionalis
Snowshoe hare**	Lepus americanus
Arctic hare	Lepus arcticus bangsii
American red squirrel**	Tamiasciurus hudsonicus
American beaver**	Castor canadensis caecutor
Muskrat**	Ondatra zibethicus obscurus
Meadow vole	Microtus pennsylvanicus terraenovae
Red Fox**	Vulpes vulpes deletrix
American black bear	Ursus americanus hamiltoni
American marten	Martes americana americana
Ermine (short tailed weasel)**	Musela erminea
American mink**	Mustela vison
River otter	Lontra canadensis degener
Lynx**	Lynx lynx subsolanus
Caribou**	Rangifer tarandus caribou
Moose**	Alces alces americana

SOURCE: Slaney (1979)

**Sighting or evidence of presence during field work

i. Moose

Moose were successfully introduced into Newfoundland in 1904 and since then have become an important big-game species (Northcott, 1964). Lowland, marshy habitat are heavily utilized by moose for calving and during the summer with intensive utilization of aquatic vegetation. Summer diet also includes leaves and twigs from broadleaved trees and shrubs as well as sedges and grasses. Lowland, marshy habitats also provide protective cover for calves which may be preyed upon by black bear.

Winter range includes lowland areas or forest slopes where food is plentiful. Primary winter food is balsam fir which is intensively utilized (Pimlott, 1959, Bergerud and Manuel, 1968). Birch, willow and other shrubs are also utilized. When snow is deep, favourable feeding areas may attract a number of moose together in a 'yard'. Suitable yards are repeatedly used each year and as such, represent permanently utilized areas.

In Newfoundland, moose have often exceeded the range carrying capacity due to lack of natural or human controls. This has resulted in widespread overbrowsing (Bergerud and Manuel, 1968). Populations on the island are presently governed by reproductive physiology associated with range conditions and human exploitation. Over population in relation to food supply is the chief reason for the low productive rate of certain moose herds. Where accessibility to hunting is high, the moose population has a high net productivity, decreased natural mortality and animals are in good condition.

If population increases go unchecked, a declining level of habitat quality occurs. The condition of the herd declines and subsequently, productivity decreases (Thurlow, 1974).

Results of the Slaney (1979) field program are presented in Tables 18 and 19. In winter (December) 31 animals were observed with a density of 0.6 moose/km^2; 54% of those observed were males. Habitat selection varied with 49% found along river or lake shorelines, 26% in forest and 17% in bogs. In spring approximately the same number of moose were observed per flight with a density of 0.5 moose/km^2. Habitat selection changed considerably with the majority (more than 85%) found in forest habitat.

Table 18

Age and Sex Distribution of
Moose Observed During Aerial Surveys At
Cat Arm, December, 1977 and April, 1978

		Adult					
	Date	Male	Female	Unknown	Yearling	Calf	Total
Moose	3/ 7/77	-	-	-	-	-	-
	20/12/77	15	13	5	1	1	35
	17/ 4/78	10	5	15	2	1	33
	20/ 4/78	8	6	5	4	-	23

SOURCE: Slaney, 1979

The major thrust of the Northland (1980) field program was directed toward caribou, however information on moose numbers and distribution was

Table 19

Habitat Type Selection by Moose, Observed During Aerial Surveys at Cat Arm December, 1977 and April, 1978

			Forest Characteristics							
	TOTAL MOOSE	Forest No. (%)	bF* X	bS X	wB X	Ht. X	Dens. X	Lake/ River No. (%)	Peat No. (%)	Scrub No. (%)
December 20										
Animals	31**	8 (26%)	6.4	3.6	-	34.3 (10.4)	0.6	17 (49%)	6 (17%)	0
Tracks	105	25 (23%)	4.5	5.3	-	36.2 (11.0)	0.6	70 (67%)	4 (3.8%)	6 (5.7%)
Unoccupied Beds	5***	1 (20%)	5	5	-	25.0 (7.6)	0.3	4 (80%)	0	0
April 17										
Animals	33	28 (85%)	8.3	2.9	0.5	40.0 (12.2)	0.5	2 (6%)	2 (6%)	0
Tracks	55	33 (60%)	6.0	3.9	0.1	34.2 (10.4)	0.7	6 (7%)	6 (7%)	10 (12.3%)
Unoccupied Beds	3	3 (100%)	5.3	4.7	-	35.0 (10.7)	0.5	0	0	0
April 20										
Animals	23	23 (100%)	8.7	3.4	-	34.7 (10.6)	0.5	0	0	0
Tracks	109	85 (78%)	5.8	4.0	0.40	34.5 (10.5)	0.6	1 (0.9%)	2 (1.8%)	22 (20.2%)
Unoccupied Beds	20	20 (100%)	6.3	3.4	-	40.0 (12.2)	0.6	0	0	0

*bF - balsam fir (6.4 = 64% of stand)
bS - black spruce
wB - white birch
Ht. - Height - feet (metres)
Dens. - Stand density (0.6 = 60%)

**X of bF, bS based on sightings in forest only, e.g. Dec. 20, 8 of moose seen in forest. Four more were seen in areas outside biophysical land typing.

*** Only unoccupied beds in this figure. Most moose observed were bedded down.

SOURCE: Slaney, 1979

collected incidentally during the caribou studies (Northland, 1980). According to Pimlott (no date) the largest "good" moose range on the Northern Peninsula is along the western coastal plain and across the northern third of the peninsula. The best moose range on the east side is found in the river valleys leading into the Long Range Mountains. The alpine barrens on the west side of the Long Range Mountains is submarginal habitat for moose.

Mercer and Manuel (1974) reported that the western coastal plain and the northern third of the Northern Peninsula which are accessible to hunters were heavily harvested and overharvested respectively.

The Long Range Mountains in the vicinity of the Cat Arm Development are inaccessible and hence the moose population is underharvested. Moose Management Area 3 (Harbour Deep) which is located on the east side of the peninsula and contains much of the Long Range Mountains had one of the highest moose populations (1.02 moose/km^2) on the island (Mercer and Manuel, 1974). In an attempt to stabilize or decrease this population and prevent overbrowsing, winter hunting seasons have been used (Mercer and Strapp, 1977). In 1974, the highest number of moose seen per hunter-day (1.04) was reported in Area 3 and hunter success was higher than average in that area (Strapp and Mercer, 1975). In that year 206 moose were taken in Area 3 during the winter season with 75% hunter success.

The distribution surveys conducted by Northland in 1980 indicate the moose numbers remain high in Area 3. Tracks were particularly numerous in April

(Figure 24). The best habitat appears to be in river valleys and near ponds (as noted by Pimlott, no date) where the majority of moose and track sightings occurred.

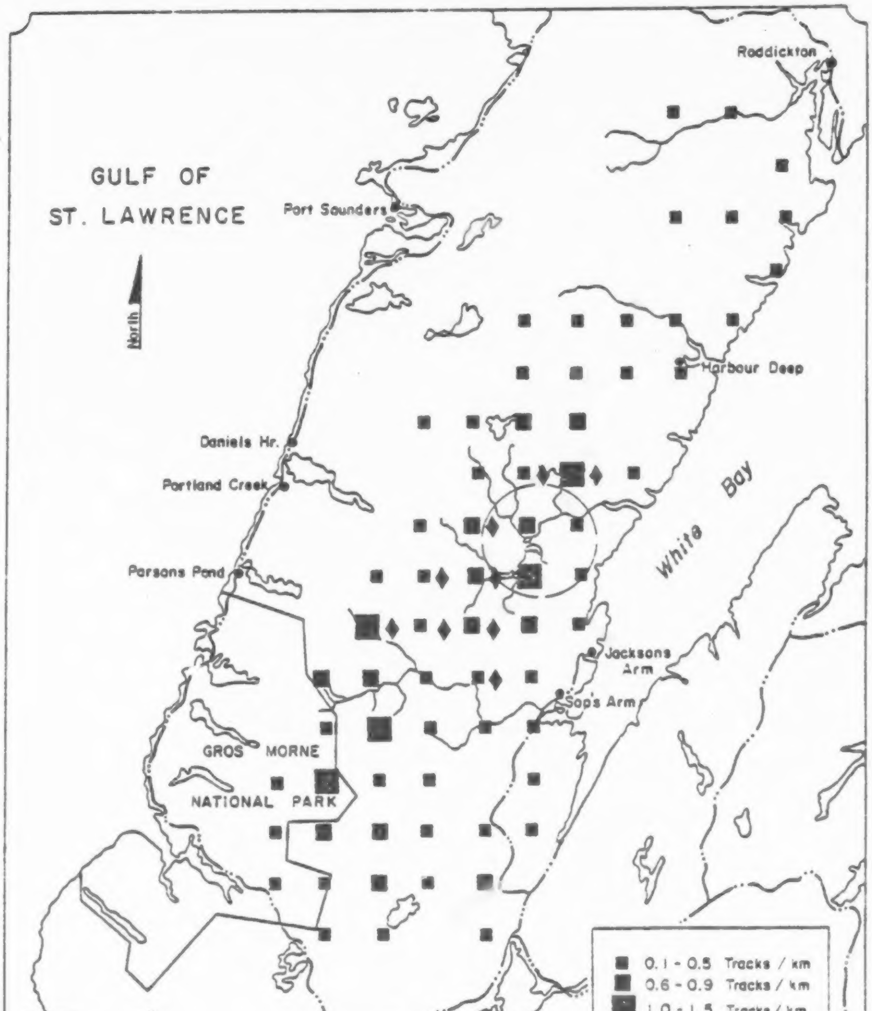
ii. Caribou

Aerial surveys were conducted during October and November 1979 by the Wildlife Division; during January, February, April and June 1980 by Northland Associates (for Hydro); and during May and June 1980 by Parks Canada. Using a fixedwing aircraft flying at an altitude of 92 m (300 ft), seventeen east-west transect lines were flown at 10 km intervals from Adies Pond in the south to Cloud River in the north. An additional six lines spaced five kilometers apart were flown in June 1980 in an attempt to locate the calving grounds (Figure 25). Ten caribou were radio-collared by Newfoundland Wildlife Division in March 1980, monitored by Northland in April and June 1980, and by Parks Canada in May and June 1980.

The following summarizes the results of this study as presented in reports prepared by Northlands (1980), Skinner (1980), and Parks Canada (1980).

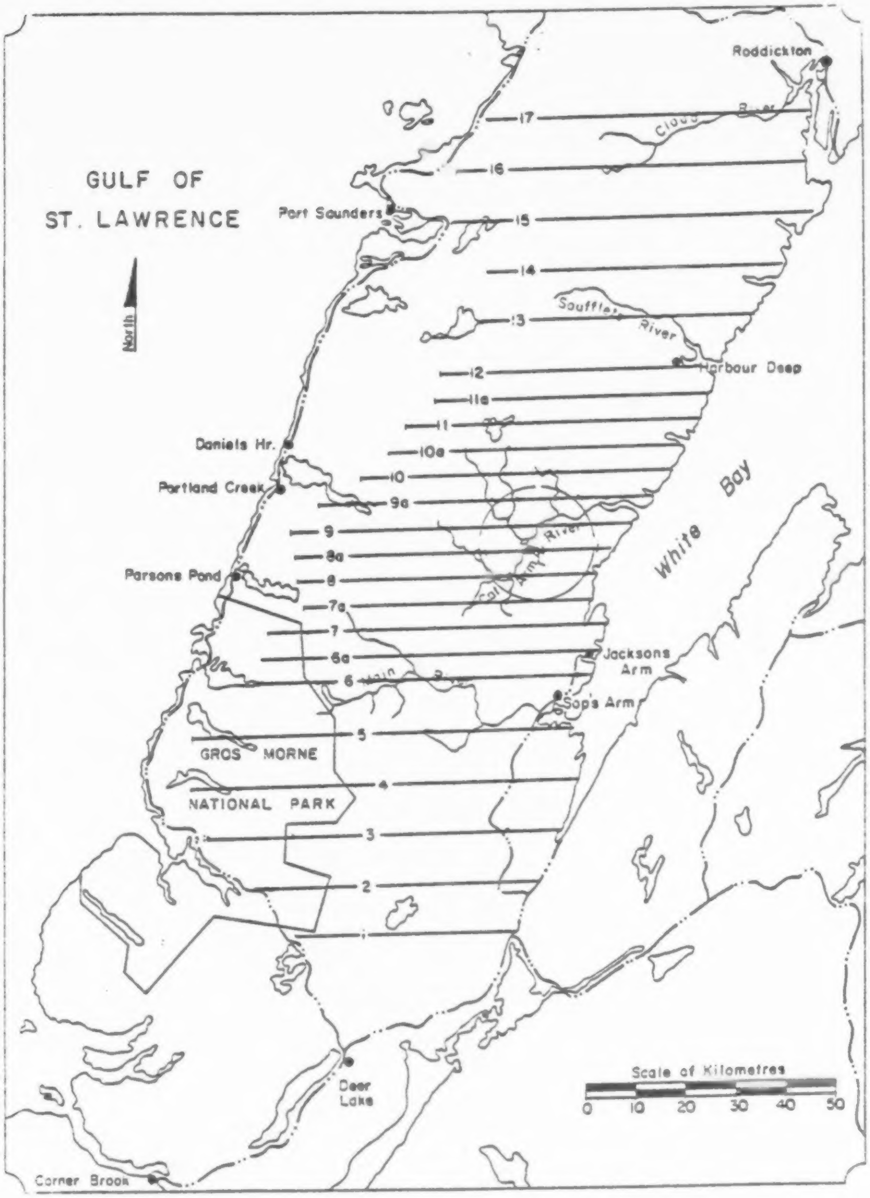
The caribou population of insular Newfoundland has fluctuated dramatically during the twentieth century. According to Bergerud (1971), the population peaked between 1900 and 1910 at approximately 40,000 animals. He attributed this phenomenon to the extinction of the Newfoundland wolf, a low lynx population, and relatively light hunting pressure due to difficulty of access. A rapid decline (due primarily to heavy hunting pressure) followed, with the nadir

Figure 24. Moose Track Density During the Late-winter Distribution Survey.


GULF OF
ST. LAWRENCE
North
Roddickton
Port Saunders
Harbour Deep
Daniels Hr.
Portland Creek
Parsons Pond
White Bay
Jacksons Arm
Sop's Arm
GROS MORNE
NATIONAL PARK
Deer Lake
Corner Brook
0.1 - 0.5 Tracks / km
0.6 - 0.9 Tracks / km
1.0 - 1.5 Tracks / km
Yard
Scale of Kilometres
0
10
20
30
40
50

SOURCE: Northlands, 1980

Figure 25. Caribou Distribution Survey Lines


GULF OF
ST. LAWRENCE
North
Roddickton
Cloud River
Port Saunders
17
16
15
14
13
Soufflets River
Harbour Deep
12
11a
11
10a
10
9a
9
8a
8
7a
7
6a
6
5
4
3
2
1
Daniels Hr.
Portland Creek
Parsons Pond
White Bay
Cat Arm River
Main River
Jacksons Arm
Sop's Arm
GROS MORNE
NATIONAL PARK
Deer Lake
Corner Brook
Scale of Kilometres
0
10
20
30
40
50

SOURCE: Northlands, 1980

(1,000-2,000 caribou) occurring in 1930. Since 1930, the population has fluctuated but increased to a present level of approximately 30,000 animals (J. Hancock, pers. comm.).

The Northern Peninsula is occupied by two major herds - the Humber Herd and the Northern Peninsula Herd. Throughout the twentieth century the population of these herds has fluctuated widely.

Bergerud (1971) estimated the population on the peninsula north of Bonne Bay to be approximately 6,500 in 1900. By 1930, the Northern Peninsula and Humber Herds numbered less than 100 animals each. Surveys in 1958 and 1966 indicated that the Northern Peninsula herd had increased to approximately 400. Despite the facts that there was no hunting season between 1957 and 1967 and that calves comprised 19% of the population in 1961, the herd did not increase during that 10 year period. Bergerud (1971) attributed this to illegal hunting which removed 150 caribou in 1959 alone. In recent years each herd has continued to grow so that presently the Northern Peninsula Herd is estimated to contain approximately 1100 animals; the Humber Herd approximately 350 (Northland, 1980, Skinner, 1980). Table 20 summarizes census data for both herds.

Historically, the distribution and range of caribou on the Northern Peninsula has been identified as a 10,000 square kilometre area from the Roddickton road in the north to Adies Pond in the south, extending approximately 220 km from north and south and 60 km from White Bay to the western edge of the Long Range Mountains.

Table 20

Population Counts of Northern Peninsula and Humber Caribou Herds

	Humber Herd	Northern Peninsula Herd
1900[1]		6,500
1930[1]	100	100
1956	130	
1958		450
1965	115	
1966		400
1975	173	
1976	179	
1977	136	
1978	204	
1979		1,140
1980	350	

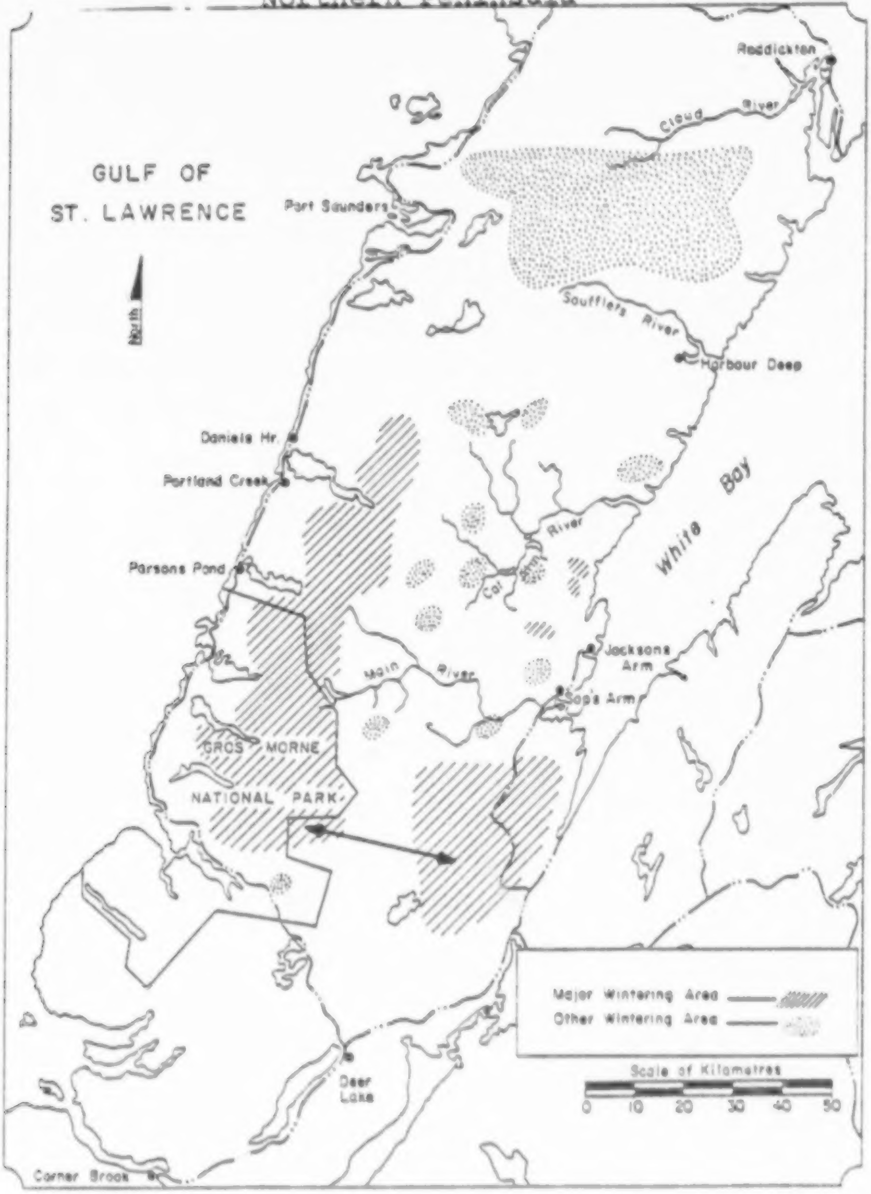
1. estimates (Bergerud, 1971)

SOURCE: Northland, 1980; Skinner, 1980; Fry, 1980.

The Humber Herd winters in the Adies Pond area and calves in Gros Morne National Park between Western Brook Pond and Bakers Brook Pond (W. Skinner, pers. comm.). The range of the Northern Peninsula Herd has not been as clearly defined as that of the Humber Herd. Pruitt (1970) stated that these caribou winter on the alpine barrens along the western edge of the Long Range Mountains and their summer range is the eastern slopes of the Long Range, including the Cat Arm River watershed. Shawmont (1980) reported three smaller wintering grounds near the Cat Arm River (Figure 26). Two calving grounds, one northeast of Parson's Pond and the other east of Portland Creek, have been identified and W. Skinner (pers. comm.) has postulated that a third may exist near the headwaters of the Torrent and Cloud Rivers. An unknown amount of interchange between these herds occurs where their ranges overlap in Gros Morne National Park.

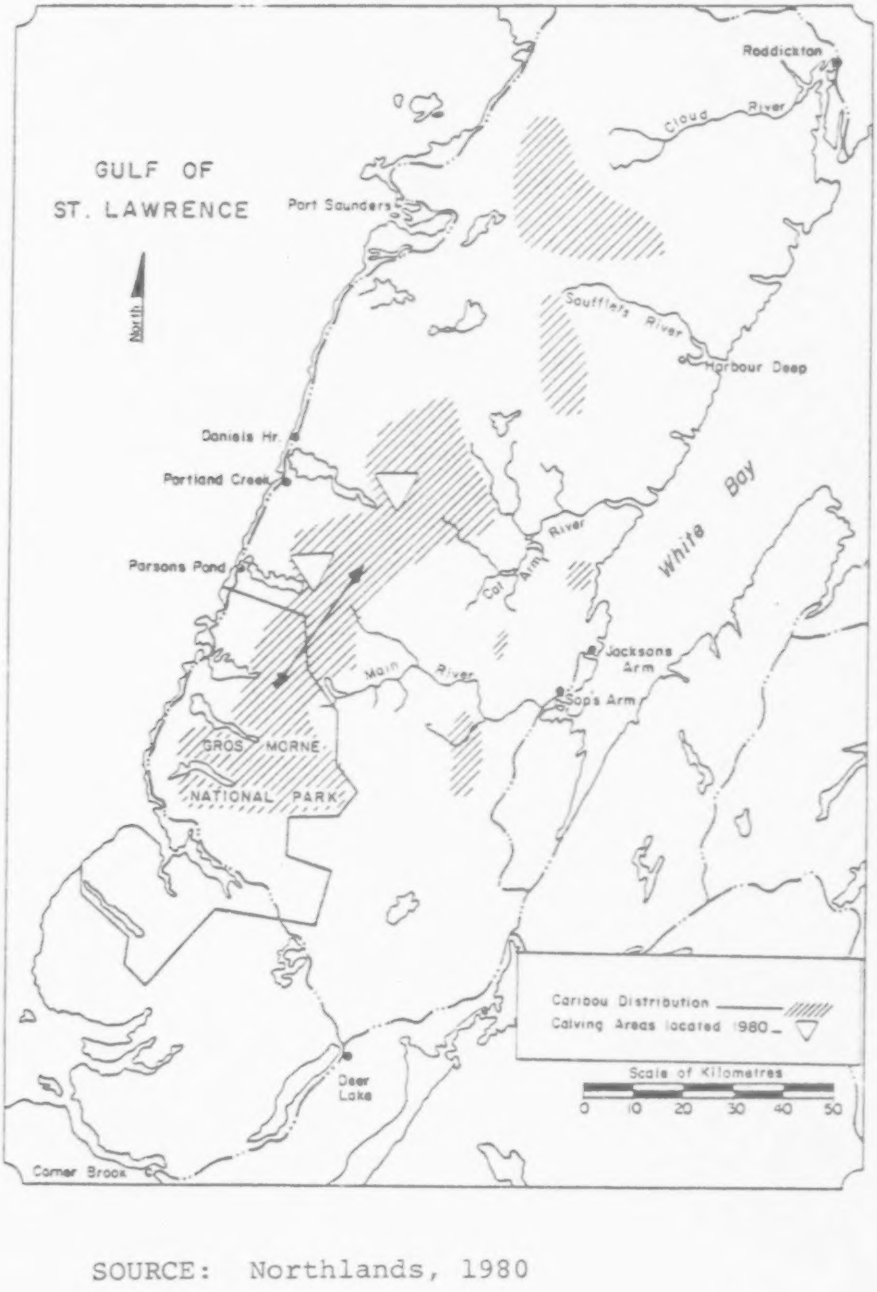
One of the major objectives of the Cat Arm caribou study was to determine the seasonal distribution of the Northern Peninsula herd. Data gathered by the Wildlife Division between 1975 and 1979 and by Northland in 1980 suggests that most of the range of the Northern Peninsula herd is contained within the area between Lake Michel in the north and Bakers Brook Pond in Gros Morne National Park in the south (Figures 26 and 27). In June 1975 and February 1976, 108 and 74 animals respectively were observed south of Portland Creek Pond on the western edge of the Long Range Mountains (Menchenton, 1975 and Greene, 1976). In March and October 1977, 105 and 115 caribou respectively were observed slightly south of that location between Parsons Pond and St. Pauls Inlet (Menchenton, 1977 and 1978). Two groups of caribou (127 and approximately 150) were observed approximately 20 km east of Portland Creek Pond and Parsons Pond in June 1979 (W. Skinner, pers. comm.). Skinner (1980) observed 45 caribou between the headwaters of the

Figure 26. Wintering Distribution of Caribou on the Northern Peninsula


GULF OF ST. LAWRENCE
North
Roddickton
Cloud River
Port Saunders
Soufflets River
Harbour Deep
Daniels Hr.
Portland Creek
Parsons Pond
River
Cat Arm
White Bay
Jacksons Arm
Main River
Sop's Arm
GROS MORNE NATIONAL PARK
Deer Lake
Corner Brook
Major Wintering Area
Other Wintering Area
Scale of Kilometres
0
10
20
30
40
50

SOURCE: Northlands, 1980

Figure 27. Distribution of Caribou on the Northern Peninsula in June, 1980


GULF OF
ST. LAWRENCE
North
Roddickton
Cloud River
Port Saunders
Soufflets River
Harbour Deep
Daniels Hr.
Portland Creek
Parsons Pond
Cat Arm River
White Bay
Jacksons Arm
Sop's Arm
Main River
GROS MORNE
NATIONAL PARK
Deer Lake
Corner Brook
Caribou Distribution
Calving Areas located 1980
Scale of Kilometres
0
10
20
30
40
50

SOURCE: Northlands, 1980

Main and Cat Arm Rivers in late October 1979 and suggested that this was the main fall concentration of the Northern Peninsula herd.

These reports suggest that the major winter and spring concentrations of this herd occur on the western edge of the Long Range Mountains. However, in March 1976, 78 caribou were observed in the Cat Arm project area (Menchenton, 1976). It was noted that these animals were scattered over a large area and "stayed in the heavy woods." It is possible that these caribou had shifted from the wintering area on the west side of the mountains where 74 were observed in February, but it seems more likely that they were using the wintering grounds identified by Shawmont (1980).

The small number of caribou trails detected near the Cat Arm development compared to the Lake Michel area during the air photo interpretation exercise suggests that this area is of secondary importance to caribou.

Both Slaney (1979) and Shawmont (1980) reported observing small numbers of caribou and some tracks and cratering activity in or near the Cat Arm development area in the fall and winter. These caribou are probably a segment of the Northern Peninsula herd which winters on the east side of the peninsula. It is unknown whether they summer in this area or move into the centre of the peninsula and mix with the rest of the herd. Interactions of these herd segments during the rutting period are also unknown.

The surveys conducted by Northland in 1980 suggest that most of the caribou in the Northern Peninsula herd are found on the barrens on the west side of the Long Range Mountains in winter and spring. However, some animals were found scattered across the peninsula.

The survey data appears to confirm Pruitt's (1970) statement that caribou winter along the western edge of the Long Range. It also appears very likely that their summer range is the eastern slopes of the Long Range, including the Cat Arm watershed. W. Skinner (pers. comm.) felt that after calving, the Northern Peninsula caribou move onto the bogs and fens in the centre of the peninsula to take advantage of new vegetation growth. However, the summer and fall ranges of this herd have not yet been clearly defined.

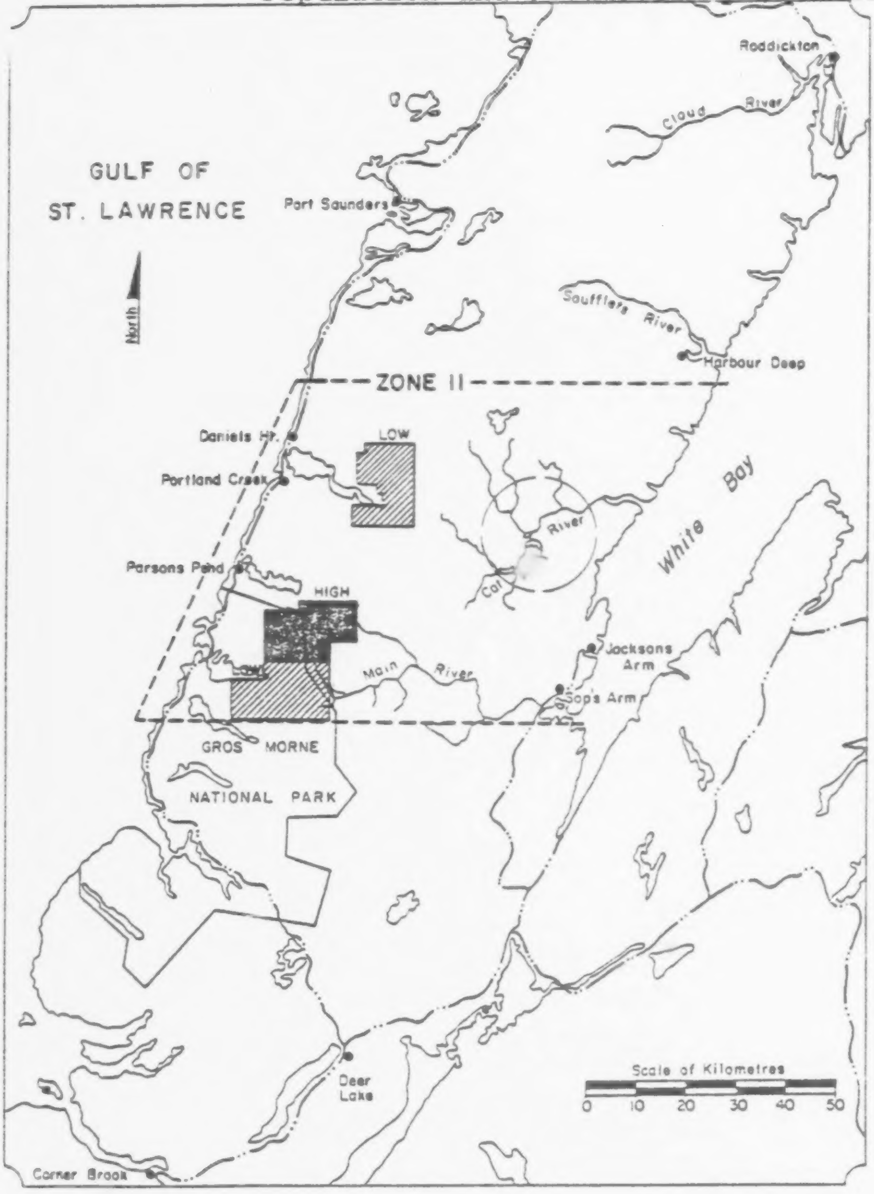
Bergerud (1974a) observed that the size of the caribou aggregations vary during their annual cycle. The largest aggregations occur during the post-calving and rutting periods. During the winter they are scattered in small bands and then in the spring the does begin to band together and move toward the calving ground. The does are frequently alone during parturition but then congregate during the post-calving period. Although no significant movement was observed during the 1980 surveys, the mean number of caribou per group increased from 4.9 in January-February to 9.8 in April to 16.2 in June. This increase agrees with Bergerud's (1974a) cycle of aggregating behaviour.

According to Bergerud (1974a), the largest post-calving herds disband in July when the fly season begins. In eastern Newfoundland the caribou disperse into forest cover while in the western and southern parts of the island they seek relief from flies on windswept ridges and snowfields. It is unknown whether the Northern Peninsula herd remains on the barrens to escape flies or moves east into the forested areas. They may utilize the barrens until the flies abate in late-August or early-September and then move east.

The second major objective of the Cat Arm caribou study was to estimate the number and productivity of caribou within the area between Lake Michel in the north and Gros Morne National Park in the south (Zone II, see Figure 28). This section of the study area appears to be the core of the range of the Northern Peninsula herd. Based on the population estimate for this area (523 ± 261), Skinner's (pers. comm.) estimate of the size of the herd (800-1,000 animals) appears to be reasonable. His estimate is also supported by Northland's estimate (1,195 ± 1,131) for the entire Northern Peninsula which was based on the late-winter distribution survey. Although this latter estimate is certainly not precise, it is an indication of herd size.

The sex ratio among Zone II animals older than one year was found to be 53 stags:100 does. The sex ratio of adult caribou (older than two years) would be slightly lower. This approximates the sex ratio of about 1:2 which Bergerud (1974b) reported to be a species characteristic.

Figure 28. Stratification of Zone II for Caribou Population and Productivity Estimate


Roddickton
Cloud River
GULF OF ST. LAWRENCE
Port Saunders
North
Soufflets River
Harbour Deep
ZONE II
LOW
Daniels Hr.
Portland Creek
Cat River
White Bay
Parsons Pond
HIGH
LOW
Main River
Jacksons Arm
Sop's Arm
GROS MORNE NATIONAL PARK
Deer Lake
Corner Brook
Scale of Kilometres
0 10 20 30 40 50

SOURCE: Northlands, 1980

The caribou were placed in two broad categories (calves and those older than one year) because it is difficult to distinguish adults from two-year-olds and large yearlings at this season. Also, although pregnant does usually have antlers until parturition, Bergerud (1971) reported that only 88 ± 9% (95% confidence limits, based on one classification) of the does in the Northern Peninsula herd possessed hard antlers in October and November. This proportion varied from 9 ± 4% to 71 ± 8% in other herds on the island.

Caribou suffer a high mortality rate during the first year of life. Bergerud (1971) estimated that 69% of the calves die before the age of six months. Mortality is higher among male calves as the sex ratio at birth (106 males:100 females) drops to about 62 males:100 females by six months (Kelsall, 1968).

Because of high calf mortality, the productivity of big game populations is best measured by the occurrence of yearlings (Pimlott, 1959). The calves (short yearlings) observed in April in Zone II have survived the period of peak mortality and may be considered the annual increment. The proportion of calves (23.7%) observed by Northland was slightly lower than that reported by the Wildlife Division in March 1976 (28%) and March 1977 (30%) (Menchenton, 1976 and 1977). These productivity figures are all higher than the 19% reported by Bergerud (1971) for October 1961.

The natural mortality rate of caribou in Newfoundland has been estimated at 5 - 10% (Bergerud, 1971). As mentioned previously, illegal hunting prevented the Northern Peninsula herd from increasing between

1957 and 1967 (Bergerud, 1971). By the early 1970's, improved enforcement had reduced poaching in this area to a more acceptable level. In 1974, Caribou Management Area 69, which contains the Northern Peninsula herd, was opened for the first season (stags only). Fifty-three licences were issued and 16 caribou were taken. Between 1975 and 1979, 100 licenses were issued annually (except 1978 when 53 were issued). Fifty percent of these licences were stags only, and the remainder were for either sex. The kill in those five years was 30, 44, 28, 23 and 46 caribou (M. Strapp, pers. comm.).

In summary, the proposed Cat Arm Development is located within the traditional range of the Northern Peninsula caribou herd. The major calving and winter grounds of this herd are located on the western side of the peninsula in the general vicinity of Parson's Pond and Portland Creek. Utilization of the proposed Development area by caribou is limited to a small percentage of the herd and generally during winter in localized areas, and possibly summer. As such the proposed Development area does not encompass major migratory routes or critical calving and post-calving areas. Recent increases in population suggest that the Northern Peninsula herd may be recovering to historical levels and this in turn will offer increased potential for resource utilization.

iii. Furbearers

Aquatic furbearers (beaver, muskrat, mink and otter) are known to occur, but are uncommon in the proposed Development area, restricted primarily by lack of suitable habitat and food.

Beaver are the most frequent of the four species and can be found in areas with white birch and deciduous scrubs such as (Alder) (Hunter, 1980). With the exception of a few areas southwest of the proposed Development near the Main River, where birch occurs in coniferous stands, beaver habitat is very scarce. The shoreline of existing lakes and ponds are largely lined with rocks, black spruce or fir with little aspen or birch.

Average beaver populations reported for three areas on the Northern Peninsula in 1961 were 4.7/km^2 to 13.2/km^2, the highest in the province for that year (Bergerud, no date). Currently, populations in the area of the proposed Development are very low, and would only approach densities reported by Bergerud in a few very local situations. Four beaver were observed by Hunter (1980) in the proposed forebay area. The site had very limited forage available, and the small group observed had conifer stems included in the food cache. Other very old beaver signs were observed during the study, suggesting that the populations are dynamic and use the habitat until the food supply is exhausted.

Several species of terrestrial furbearers are known to occur in the proposed Development area including pine martin, red squirrel, snowshoe hare, red fox and lynx. These species occur most often in fir-spruce woodland areas.

The red squirrel is the most common of these mammals. Signs of its presence and observations of individuals were made throughout the study area. Five species of small mammals were identified by tracks along plots in representative habitats by Slaney (1979). (Table 21).

Table 21

Track Counts of Mammals Per km of Transects*, Cat Arm, April, 1978

		Species					
	No. Plots	Hare	Squirrel	Fox	Lynx	Weasel	Unidentified
1) Mature, Dense Balsam Fir(80-100%)** Black. Spruce(0-20%)	48	1.0	6.8	2.4	0.0	0.3	-
2) Mature, Dense Balsam Fir(50-70%) Black Spruce(30-50%)	48	5.1	6.5	1.7	0.3	-	-
3) Mature, Dense Black Spruce(60-100%) Balsam Fir(0-40%)	24	-	6.9	1.4	-	-	-
4) Open Conifer Stands	24	-	1.4	-	-	0.7	0.7
5) Bogs, Sedge Meadows, Wetlands	12	0.7	1.4	0.7	-	-	-
6) Scrub (Unforested Uplands), Heath	36	0.9	2.3	-	-	-	-

* Plots 61.1 m long x 4 m wide (2.44×10^{-4}ha)

** Mature - 10.7 m - 16.8 m
DEnse - 0.6 or greater (60% stocking)

SOURCE: Slaney, 1979

Six pine martin were released into the upper Main River in 1976 (Mayo, 1976). The success of this release is not known, but it is probable that, with the widespread presence of the red squirrel, martin could have spread northwards. Suitable martin habitat occurs in the Cat Arm area, and with the abundance of red squirrel, the chances for martin success are greatly increased.

No hunting or trapping of aquatic or terrestrial furbearers is known to occur in the Development area due to lack of access.

iv. Black Bears

No black bears were seen during any of the aerial surveys, but this is to be expected even in areas of dense bear population, since these animals "hibernate" in winter, and are very difficult to see in summer.

The only data available on black bears for the management area come from hunting statistics provided by the Wildlife Division. In 1976, 0.07 bears were seen per moose hunter day in the Harbour Deep area (3559 km^2). No bears were shot in the area. The ratio of cubs to adults was 0.031:1 among bears seen by moose hunters.

V. Resource Utilization:Hunting and Trapping

The wildlife resources of the Cat Arm area are exploited very little at present. No commercial hunting or trapping of aquatic or terrestrial furbearers is known to occur due primarily to lack of access and low densities of furbearers. Access to the area is by air or, in winter, by snowmobile.

The proposed Cat Arm Development area is part of caribou management Area 69 and moose management Area 3. Table 22 shows the license sales and the kill resulting from open seasons for caribou and moose since 1974. While this resource is available to all residents of the province, there is probably a greater demand for licences in these areas by residents of the surrounding area.

Table 22

Licence Sales and Success Rates
for Moose and Caribou
in Cat Arm area

	Moose (Area 3)		Caribou (Area 69)	
Year	Licence Sale	Success Rate(%)	Licence Sale	Success Rate(
1974	242	52	53	16
1975	N/A	N/A	100	30
1976	625	45	100	44
1977	599	35	100	28
1978	600	48	53	23
1979	603	51	100	46

N/A - Not Available

SOURCE: Personal Communication, Wildlife Division, 1980.

Since 1976, approximately 600 moose licences per year have been sold for Management area 3. The estimated success rate has fluctuated between 35 percent and 51 percent or from 208 to 307 moose killed per year. This represents approximately 5 percent of the total moose population within Area 3.

Caribou Management Area 69 opened for hunting in 1974. With the exception of 1974 and 1978, 100 licences were issued per year. The estimated success rate has fluctuated between 16 percent and 4.6 percent or from 8 to 46 caribou killed per year (Table 22).

3.3 Human Environment

3.3.1 Archaeology

The coasts of White Bay and the eastern side of the Great Northern Peninsula were inhabited by peoples of the Dorset culture and the Maritime Archaic tradition. Artifact sites are located at Gold Cove, Brown's Cove, Sop's Island, Pumbley Cove, Jackson's Arm, Englee and Conche. Both the Maritime Archaic (2000 to 1500 B.C,) and Dorset (AD 113 to 639) were coastal oriented peoples with secondary dependEnce on the resources of the interior. The caribou herds on the Northern Peninsula were harvested by these prehistoric hunters in their search for food and clothing. The presence of a fairly large caribou herd in small winter aggregations influenced the seasonal activities of these peoples. It is likely that they utilized the terrestrial and aquatic resources located within the Cat Arm watershed.

An archaeological survey of the proposed Cat Arm Development area was conducted during 1979 and 1980. Aerial and ground surveys of the proposed flood zone and construction sites, as well as interviews with local residents resulted in the discovery of no archaeological artifacts (Penny, 1980).

3.3.2 Demography

A study was conducted during the winter and spring of 1980 by Saga Development Limited (1980) to gather information on the existing social and economic conditions in the region closest to the proposed Cat Arm Development. The investigation included personal interviews with members of the general public and businessmen in the Cat Arm region, as well as with government officials in the field of health, education, community services, fisheries, tourism, law enforcement and public works. Relevant published and unpublished literature was reviewed and used as a source of historical and statistical information which enabled the subjectivity of the personal interviews to be placed in a more objective context. The study area included the communities of Jackson's Arm, Sop's Arm and Hampden, those closest to the proposed Development, as well as the more distant communities of Deer Lake, Cormack, Howley, Reidville, and Nicholsville.

The population of the study area according to the 1976 Population Census accounts for 7910 or 1.42% of the provincial total. The population of each community increased significantly from 1971 to 1976 with the exception of Howley, Jackson's Arm and Sop's Arm, whose populations decreased by 2.4%, 2.2% and 1.8%, respectively. Collectively the population of the study area increased by 5.65% from 1971 to 1976 or approximately 1.13% per annum compared to 1.38% for the province and 1.32% for the nation. Table 23 details the population statistics from 1966 to 1976 for each community and the province.

Jackson's Arm, Sop's Arm and Hampden are the communities closest to the development, and although

Table 23

POPULATION OF COMMUNITIES IN STUDY AREA

COMMUNITY	1966 n	1971 n	1976 n
Deer Lake	4,289	4.420	4.545
Cormack	432	565	675
Hampden	733	735	775
Howley	395	410	400
Reidville	240	248	355
Nicholsville	225	236	305
Jackson's Arm	450	491	480
Sop's Arm	n/a	382	375
TOTAL	6,764	7,487	7,910
Newfoundland and Labrador		520,000	558,000

N/A - Not Available

SOURCE: Statistics Canada

the population of Jackson's Arm and Sop's Arm decreased between 1971 and 1976, these communities are expected to grow during the next couple of years due to developments in the fishing industry.

In 1976, the male/female ratio of 52:48 differed slightly from the provincial ratio of 51:49. The population consisted of 37.1% under 15 years of age as compared to 32.8% for the province. The working age group from 15 to 64 years of age made up 57.8% of the population compared to a provincial average of 60.8%. The population distribution by age and sex in 1976 for the study area is given in Table 24 .

The weighted average family size for the study area in 1976 was 4.221 persons per family with Hampden having the highest average at 4.795 and Deer Lake the lowest (4,062). The weighted average for

Table 24

POPULATION DISTRIBUTION FOR STUDY AREA

AGE, SEX, 1976

AGE GROUP	MALE		FEMALE		TOTAL	
	NUMBER n	PERCENTAGE %	NUMBER n	PERCENTAGE %	NUMBER n	PERCENTAGE %
0 - 4	460	11.19	385	10.01	845	10.62
5 - 9	515	12.53	485	12.61	1000	12.57
10 - 14	610	14.84	495	12.87	1105	13.89
15 - 19	435	10.58	475	12.35	910	11.44
20 - 24	360	8.76	320	8.32	680	8.55
25 - 34	560	13.62	555	14.43	1115	14.02
35 - 44	385	9.37	360	9.36	745	9.37
45 - 54	335	8.15	320	8.32	655	8.23
55 - 64	245	5.96	250	6.50	495	6.22
65 - 69	105	2.55	80	2.08	185	2.33
70 +	100	2.43	120	3.12	220	2.77
	4,110		3,845		7,955	

Source: Statistics Canada

Table 25

FAMILY STRUCTURE, 1976

COMMUNITY	AVERAGE NUMBER OF PERSONS/ FAMILY n	AVERAGE NUMBER OF PERSONS SINGLE-PARENT FAMILIES n
Deer Lake	4.062	3.286
Cormack	4.380	4.300
Hampden	4.795	3.500
Howley	4.100	2.889
Reidville	4.479	3.000
Nicholsville	4.453	n/a
Jackson's Arm	4.245	n/a
Sop's Arm	4.341	n/a
Study Area	4.2	
Newfoundland	4.0	
Canada	3.5	

Source: Statistics Canada

the study area is higher than the 1976 provincial average of 4.0 and the national average of 3.5 (Table 25).

The predominant religions in the study area in 1971 were Anglican, Pentecostal, United and Salvation Army compared to Roman Catholic, Anglican and United Church provincially (Table 26).

Table 26

RELIGIOUS AFFLIATIONS OF COMMUNITIES IN STUDY AREA, 1971

COMMUNITY	ANGLICAN n	PENTECOSTAL n	UNITED n	SALVATION ARMY n	ROMAN CATHOLIC n	PRESBYTARIAN n	LUTHERAN n	BAPTIST n	OTHER n	NONE n
Deer Lake	880	875	945	1,070	605	15	-	5	65	10
Cormack	225	95	45	45	100	-	5	-	25	10
Hampden	380	100	115	95	5	-	-	-	30	-
Howley	75	75	120	65	30	-	-	-	-	-
Sop's Arm Area*	995	205	110	20	5	-	-	-	-	-
Reidville	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nicholsville	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/
TOTAL	2,555	1,350	1,335	1,295	745	15	5	5	120	20
PERCENTAGE OF TOTAL	34.3	18.1	17.9	17.4	10.0	0.2	0.1	0.1	1.6	0.3
Newfoundland	27.6	5.5	19.5	7.9	36.6	0.6	0.1	0.2	1.4	0.4

*The Sop's Arm area includes Sop's Arm, Jackson's Arm and Pollard's Point.

Source: Statistics Canada

The level of formal education, as determined by secondary school diplomas, is slightly lower for the study area than for the province. Of the population 15 years of age and older, 6.9% had obtained a secondary school diploma compared to 7.1% provincially. The percentage of the population with post-secondary, non-university diplomas corresponded with the provincial average while the percentage with a university diploma was higher. Refer to Table 27 .

Table 27

LEVEL OF EDUCATION OF THE POPULATION

15 YEARS AND OLDER IN CANADA, NEWFOUNDLAND AND STUDY AREA, 1976

COMMUNITY	SECONDARY SCHOOL DIPLOMA %	POST SECONDARY (NON-UNIVERSITY DIPLOMA) %	UNIVERSITY DIPLOMA %
Study Area	6.9	5.6	4.0
Deer Lake	8.2	7.2	4.4
Cormack	4.1	2.7	1.4
Hampden	5.7	1.1	8.0
Howley	10.4	4.2	4.2
Reidville	6.5	8.7	-
Nicholsville	2.5	2.5	5.0
Jackson's Arm	3.4	5.2	3.4
Sop's Arm	4.3	2.1	-
Newfoundland	7.1	5.6	3.6
Canada	10.9	7.7	6.4

Source: Statistics Canada

3.3.3 Labour Force and Employment

Reliable up-to-date statistics on the labour force and employment characteristics are not available for the study area. The latest statistics available are from the 1971 and 1976 census records. It is difficult to accurately extrapolate from these figures if present age structures are not known, and up-to-date information will not be available until the 1981 census has been completed. However, a general perspective for current and future employment opportunities and the labour force has been obtained through discussions with Canada Manpower officials, fisheries officials and employers in the area.

In 1976, the labour force in the study area totalled 2315 people with a participation rate of 46.6% compared to 49.4% provincially and an unemployment rate of 19.9% compared to a provincial rate of 13.4%. Jackson's Arm and Sop's Arm had the highest rate of unemployment at 40% while Deer Lake was the lowest at 13.9% (Table 28).

In May, 1980, there were 1362 individuals from Deer Lake, Cormack and Howley, and 521 from Sop's Arm, Jackson's Arm and Hampden registered at the Corner Brook Canada Manpower Centre as compared to 260 and 150 individuals, respectively, recorded as unemployed in the 1976 census. This increase appears to be rather dramatic. However, the figures include a large number of seasonal workers such as loggers and

Table 28

LABOUR FORCE AND EMPLOYMENT CHARACTERISTICS

STUDY AREA AND PROVINCE 1976

COMMUNITY	TOTAL POPULATION n	POPULATION 15+ YEARS n	TOTAL EMPLOYED n	TOTAL UNEMPLOYED n	TOTAL LABOUR FORCE n	PARTICIPATION RATE %	UNEMPLOYMENT RATE %
Deer Lake	4,545	2,965	1,265	205	1,470	49.6	13.9
Cormack	675	370	130	45	175	47.3	25.7
Hampden	775	440	105	60	165	37.5	36.4
Howley	400	240	75	15	90	37.5	16.7
Reidville	355	230	75	30	105	45.7	28.6
Nicholsville	305	195	70	15	85	43.6	17.6
Jackson's Arm	480	290	75	50	125	43.1	40.0
Sop's Arm	375	235	60	40	100	42.6	40.0
TOTAL	7,910	4,965	1,855	460	2,315	46.6	19.9
Province (1976)						49.4	13.4
(1977)						50.7	15.6
(1978)						51.7	16.4
(1979)						52.7	15.4

Source: Statistics Canada

fish plant workers who are now being recalled by employers. The majority of these employers maintain their own lists of workers for recall and do not use the Canada Manpower Centre's facilities for hiring employees. This, in addition to other factors, causes delays in updating and results in records not being accurate. Details of the registered unemployed, May 1980, are found in Tables 29 and 30.

Increased participation may be another explanation for any increase in the number of individuals unemployed. The participation rate for the province has increased from 49.4% in 1976 to 52.7% in 1979 (Table 28). In 1976, only a small portion of the female population (26.2%) were participants in the work force. With the upsurge in the fishing industry and other developments in the area, more females can be expected to take advantage of job opportunities. Most of the jobs are seasonal in nature but workers qualify for unemployment benefits when lay-offs occur. In order to obtain these benefits, individuals must register at a Canada Manpower Centre and this may account for a large portion of these registrations.

Employment in the area is provided by the fishing, logging and service industries. Jackson's Arm, Sop's Arm and Harbour Deep are heavily involved in the fishing industry. Over the past four years the number of fishermen in the area has grown from approximately 50 to slightly more than 100. This has resulted in an increase from 60 to more than 300 plant workers. The fishing season runs from late May or early June until November or early

Table 29

REGISTERED UNEMPLOYED

DEER LAKE, CORMACK AND HOWLEY

MAY, 1980

OCCUPATION	SEX	AGE GROUPS 20-25 #	26-40 #	41-55 #	55-60 #	Over 60 #	TOTAL #
Personnel Manager	M			1			1
Sales Manager	M		1				1
Manager Retail Sales	M		1				1
Construction Superintendent	M			1			1
Safety Inspector	M			1			1
Consultant	M	1					1
Prospector	M		2				2
Technician/Wildlife	M	1					1
Forest Technician	M	1					1
Field Engineering Assistant	M	1					1
Mechanical Engineer	M		1				1
Surveyors	M	5	7	1			13
Draftsperson	M		1				1
Engineering Technologist	M	3					3
Geographer	M	1					1
Financial Adviser	M		1				1
Teachers	M			1			1
	F	1	7	5			13
General Practioner	F		1				1
Nurses	F		1				1
Nursing Assistants	F	3		1			4
Nurses Aids	F		1				1
First Aid Attendant	M			1			1
Commercial Artist	M	1					1
Sales Clerk	M	6	1				7
	F	20	10	5	2		37
Service Station Attendant	M				3		3
	F				7		7
Stenos/Secretaries	F	5	3				8
Clerk Typists	F	2	2				4
Accounting Clerks	F	12	13	1			26
Cashiers	F	2	2	1			5
Waitresses	F	10	10	7	1		28
Chambermaids	F	4	3	1			8
Babysitters	F	2	1				3
Janitors	M	1	1	1			3
	F	1	1	3	1		6
Kitchen Helpers	M	3					3
"	F				1		1
Roller Operator	M	1	2				3
Linesman	M	2	2				4
Electrician	M	2	6	4			12
Electronic Repairman	M	1	4				5
Construction Foreman	M		3	3	2		8
Carpenters	M	34	20	30	5	3	92
Bricklayers	M	1	2				3
Plumbers/Pipefitters	M	2	3	2			7
Forest Officer	M	1	1				2
Forest Fire Fighter	M	1					1
Loggers	M	6	36	31	8		81
Logger Scalers	M				1		1
Logging Skidder/ Tractor Operator	M	1	11		1		13
Drilling Machine Operator	M		2	3			5
Blaster	M		1	1			2
Loading Machine Operator	M		1				1
Miner	M			1			1
Foreman/Crusher	M		1				1
Bakers	M	1					1
	F		2	3			5
Meat Cutters	M		3				3
	F		1				1
Dairy Helper	F		1				1
Saw Operator	M		1				1
Machinist	M				1		1
Saw Repairman	M				2		2
Sheet Metal Worker	M		1				1
Welding	M	7	1	1			9
Woods Foreman	M		1				1
Grinder Operator	M	1					1
Electrical Repairman Airplane	M			1			1
Repairman-Portable Appliances	M			1			1
Electronic Equipment Repairman	M	1	1				2
T.V. Repairman	M	1					1
Auto Mechanic	M	3	7	3			13
Auto Body Repairman	M		1				1
Aircraft Mechanic	M		1	1			2
Construction Equipment Mechanic	M	2	8	5	3		18
Millwright	M	5	1	1			7
Instrument Repairman	M		1				1
Auto Mechanic Helper	M	1					1
Foreman/Paving	M		1				1
Heavy Equipment Operators	M	8	36	29	6		79
Labourers	M	171	142	38	11	4	366
Pipefitters/Plumbers	M		1				1
Riggers(Iron Workers)	M	4	4	1			9
Maintenance Person	M	2	6		1		9
Tug Boat Captain	M			1	1	1	3
Marine Engineer	M		2	2			4
Deck Hand	M	1	3	3	4		11
Taxi Driver	M	1	3				4
Truck Drivers	M	30	105	34	12	1	182
TOTAL							1,262
STUDY AREA TOTAL							1,383

SOURCE: Canada Employment Centre, Corner Brook, 1980

Table 30

REGISTERED UNEMPLOYED

SOP'S ARM, JACKSON'S ARM, HAMPDEN AND POLLARD'S POINT

MAY, 1980

OCCUPATION	SEX	AGE GROUPS 20-25 n	26-40 n	41-55 n	56-60 n	Over 60 n	TOTAL n
Postmaster	F	1					1
Park Ranger	M			1			1
Forest Technician	M		1				1
Forester	M		1				1
Surveyor/Supervisor	M		1				1
Surveyors	M	1	2				3
Teachers	F		2				2
Nursing Assistants	M/F	1M, 1F	1F				3
Hunting/Fishing Guide	M/F	1		1			2
Sales Clerks	F	7	2	2			11
Driver Salesperson	M			1			1
Security Guard	M/F	1M, 1F		1M			3
Conservation Officer	M/F	4M	4M, 1F	3M		1	13
Cooks	M/F	2M, 1F	2	2	2		9
Bartenders	F		1				1
Waitresses	F	5	3	2			10
Chambermaid	F		1	1			2
Chore Person	M			1			1
Stewards	M			1			1
Babysitters	F	4					4
Janitors	F			3			3
Kitchen Helper	F	1					1
Flagmen	M			2			2
Linemen	M	1					1
Foreman-Construction	M		3				3
Stenos/Secretaries	F	3	2				5
Accounting Clerks	F	2	3	1			6
General Office Clerk	M/F	1M	2M,2F				5
Sales Representative	M	2		1			3
Fishermen	M	3	2	1	2		8
Loggers	M	10	56	22	6		94
Skidder Operators	M		5				5
Foreman-Crisher	M	1		1			2
Meat Cutter	M		1				1
Fish Plant Workers	M	9	3	2	2		16
	F	10	31	16	5	1	63
Welders	M		1				1
Air Frame Assembler	M			1			1
Electrical Repairman Helper	M			1			1
Electronic Repairman	M		1				1
T.V. Repairman	M	1					1
Auto Mechanic	M		2				2
Construction Equipment Mechanic	M	1	3	1			5
Diesel Mechanic	M			1			1
Millwright	M			1			1
Marine Mechanic	M	1					1
Spray Painter	M		1				1
Heavy Equipment Operator	M	1	10	9			20
Construction Foreman	M		2	2			4
Carpenters	M	6	6	5	5	3	25
Painters	M	2					2
Iron Workers	M	1	1				2
Maintenance Person	M	1					1
Bus Driver	M	1	6	2	1		10
Truck Drivers	M	10	18	11			39
Cashiers	F	4	2	2			8
Shipping/Receiving Clerk	M			1			1
Stock Clerk	M	1					1
Labourers	M	49	43	7	5		104
TOTAL							521

Source: Canada Employment Centre, Corner Brook, 1980

December. In addition, approximately 60% of the fishermen are involved in the seal hunt along the coast from January until April or when the season closes. (Source: Provincial Fisheries, Field Office, Port Saunders).

Bowaters employs approximately 270 individuals from the study area in their woods operations. These woodsmen would be employed from January to March and from June until mid-November. (Source: Bowaters Newfoundland Limited, Woods Personnel, Corner Brook).

In summary, the labour force participation rate with the exception of Deer Lake, has been lower than the provincial average while the unemployment rate in the study area has been higher. Information obtained indicates that the participation rate has been increasing while the unemployment rate has been decreasing since 1976.

3.3.4 Housing

A critical housing shortage exists in the Jackson's Arm/Sop's Arm area, and this is aggravated by the fact that very little developed land suitable for housing existing there. This shortage has developed with the expansion of the fish plants. Boarding houses are filled and a lot of private homes are accommodating one or two boarders. Seven or eight new homes are under construction but a lot of one-room dwellings and mobile homes are appearing throughout the communities.

The most recent statistics available are from the 1971 and 1976 census. Table 31 contains information on the age of the occupied dwellings in

Table 31

OCCUPIED DWELLINGS BY PERIOD OF CONSTRUCTION 1971

Year Built	Cormack	Hampden	Howley	Deer Lake
1971	-	-	-	5
1970	5	-	-	25
1969	-	5	-	30
1966-68	5	5	15	65
1961-65	10	15	-	90
1951-60	5	55	20	285
1946-50	70	20	15	170
1921-45	-	20	25	225
Pre	-	5	15	15
Total	100	125	90	915

SOURCE: Statistics Canada

Table 32

TOTAL OCCUPIED PRIVATE DWELLINGS 1976

TYPE OF HOME	CORMACK	HAMPDEN	HOWLEY	DEER LAKE	JACKSON'S ARM	SOP'S ARM	NICHOLSVILLE	REIDVILLE
Double	5	5	10	60	-	5	5	-
Row	-	-	-	15	-	-	-	-
Attached to non/res. structure	-	-	-	25	-	5	-	-
Single Attached Total	5	10	5	95	-	10	5	-
Single Detached	120	125	80	865	105	70	50	65
Apartment	5	-	-	55	-	-	-	-
Duplex	-	-	-	25	-	-	5	-
Movable	15	10	-	15	-	-	10	-
TOTAL	140	145	90	1055	110	80	65	75
Total Rented	5	30	25	375	0	15	0	5

Source: Statistics Canada

1971. The types of homes located in each community are found in Table 32. It is not possible to quantify any increase in housing since current statistics are not available for the study area.

3.3.5 Land Use

A. Jackson's Arm

This community stretches from "The Bottom" to Godfather Cove, a distance of about 4 km. Side roads add about another 0.8 km of development. Most of the development is in ribbon form with varying scales of density and set back. There is a barren portion about 274 m in length at the foot of the cliffs along the westerly shore of Schooner Cove. Both fish plants are located at the Bottom.

Apart from infilling lots which exist in several areas, there are larger tracts of reasonably flat, undeveloped land, e.g. 0.4 hectare upwards to 2 hectares. These larger tracts lie west of Schooner Cove up to the Bottom.

B. Sop's Arm

The community is in two parts around Sop's Arm harbour, with Pollard's Point on the south shore and Sop's Arm on the north shore. Generally housing density is light in Sop's Arm, with space for infilling. The centre of Sop's Arm lies in the area of Western Tickle, where there is a church, high school and fish plant.

There is a large area of flat land on the main highway immediately north of the Pollard's Point turnoff. This site is between Pollard's Point and Sop's Arm but is remote from either.

C. Hampden

Hampden has developed in four areas:

The Beaches	20 houses, spread out
The Rooms (shown as Galeville on the Plan)	40 houses, fairly dense
Hampden proper	100 houses - dense
Bayside	50 houses - spread out

The estimates of housing are very approximate and are intended to give a general idea. The community overall stretches out over about 17 km but with considerable intervening areas which are not built up. On a parallel road to Bayside there is a large integrated high school and a few other houses.

3.3.6 Community Services Profile

A. Governing Bodies

Of the communities in the study area, Deer Lake, Cormack, Hampden, Howley and Reidville are incorporated with town councils/community councils. The other communities in the study area obtain administrative assistance from the provincial government.

Table 33

MUNICIPAL AND PUBLIC SERVICES

	REIDVILLE	NICHOLSVILLE	CORMACK	DEER LAKE
Medical Availability	None	None	None	Dept. of Health Clinic with full time nurse, 3 M.D.'s, fully equipped x-ray with technicians. Med Lab with Lab Technician, 1 Dentist, Ambulance Service to Corner Brook (50 km).
Educational Facilities	K-3, 40 enrolled	None	K-6, 123 enrolled	K-11, 4 Elementaries, 1 Junior High, 2 High Schools, School for Retarded Students, 1476 enrolled.
Religious Facilities	Anglican Church (Minister in Deer Lake)	None	Anglican Church (Minister in Deer Lake)	R.C. (Church and Priest) Anglican (Church and Minister) S.A. (Church and Captain) U.C. (Church and Minister) Pentecostal (Church, 2 Pastors) Jehovah's Witness (Hall)
Communications Media	CBC TV and Radio (Corner Brook) Private Radio (Corner Brook)	See Reidville	See Reidville	CBC TV and Radio (Corner Brook) Private Radio (Corner Brook) FM (OZ-St. John's) CTV (Corner Brook) Cable TV (ABC,NBC,Bangor, Me.) Western Star Newspaper (Corner Brook) 2200 Telephone Lines.
Law Enforcement	Deer Lake R.C.M.P.	Deer Lake R.C.M.P.	Deer Lake R.C.M.P.	R.C.M.P. Detachment and Highway Division (Total 12 Officers).
Volunteer Organizations	None	None	None	Lions, Masons, Legion, Orange (all have buildings), St. John's Ambulance, Volunteer Fire Brigade.
Hotel/Motel	None	None	Rocky Brook Cabins (4 units-2 bedrooms each	Deer Lake Motel (55 rooms) Hotel St. George (24 rooms).
Other Government Services	None	None	Post Office Door to Door Mail Delivery	Post Office, Fisheries Office, Weather Info, Airport, CNR Tool Shed, Agriculture Station, Highways Depot, Driving Examiner Forestry Office, Wholesale Veg. Dist.

Table 33 (Cont'd)

MUNICIPAL AND PUBLIC SERVICES

	JACKSON'S ARM	SOP'S ARM	HOWLEY	HAMPDEN
Medical Availability	Dept. of Health Clinic with full time nurse. M.D. one day a week from Hampden (72 km). Dentist one day a week from Sop's Arm (16 km).	One Dentist. M.D. one day a week from Hampden (56 km).	None	Dept. of Health Clinic with M.D.
Educational Facilities	K-8, 151 enrolled-March 1980 9-11 bus to Sop's Arm (16 km). Plan to bus Grade 8 students (19) Sop's Arm in September 1980. Site for new school being acquired. No definite plans for construction.	Primary K-3, 40-50 enrolled. Elementary K-5 (Pollard's Point - 2 km), 128 enrolled High 6-11, 147 enrolled.	K-8, 91 enrolled. 7-11 Bus to Deer Lake (50 km).	K-6, 210 enrolled. 7-11, 119 enrolled.
Religious Facilities	Anglican Church (with Minister).	Anglican Church (Minister in Jackson's Arm). Pentecostal Church (Pastor) United Church (largely inactive).	Anglican Church (Minister-Deer Lake) Roman Catholic Church United Church Pentecostal Church	Anglican (Minister U.C. (Church), S.A. (Church and Capt.) Jehovah's Witness, Pentecostal Church (Pastor)
Communications Media	CBC TV, CBC Radio(Grand Falls) Private Radio (Grand Falls) 150 telephone lines (50 more are planned for 1980)	See Jackson's Arm for TV and Radio - 150 telephone lines 220 planned total in 1981	See Jackson's Arm for TV and Radio Telephone Deer Lake exchange with direct dialing.	See Jackson's Arm for TV and Radio 150 telephone lines (240 Planned total in 1981)
Law Enforcement	Deer Lake R.C.M.P.	Deer Lake R.C.M.P.	Deer Lake R.C.M.P.	Deer Lake R.C.M.P.
Volunteer Organizations	Recreation Committee (has building)	Recreation Committee (has building)	None	None
Hotel/Motel	2 Boarding houses (uncertified)	None	None	Motel, 12 Units
Other Government Services	Post Office	Forest Ranger Station Highways Depot	CNR Tool Shed	Post Office, Hydro Plant

SOURCE: Saga Development Ltd., 1980

B. Municipal and Public Services

A summary of the municipal and public services available in each community are summarized in Table 33. An additional comment should be made regarding educational facilities in the area. The primary/elementary school at Jackson's Arm is overcrowded and plans now exist to bus grade 8 students to the high school at Sop's Arm beginning in September, 1980, and grade 7 students in 1981. The high school at Sops's Arm is capable of supporting an additional 25% or 50 students however, capacity will be reached with the addition of the Jackson's Arm grade 7 and 8 students.

C. Transportation

i. Ground

The present road system from Deer Lake to Jackson's Arm includes the Trans Canada Highway and Route 420, and is categorized as follows:

	Distance (km)	Condition
1) Deer Lake to Hampden Road turn off	44.8	T.C.H. pavement
2) T.C.H. to Sop's Arm turn off along the Hampden Road	9.3	Reconstructed gravel (route 420
3) Hampden Road to Pollard's Point turn off	42.6	Low standard gravel (route 420)
4) Pollard's Point junction to Jackson's Arm	17.0	New constructed gravel (route 420)
TOTAL	113.7 km	

The total distance is 39% paved and 37% low standard gravel.

ii. Marine

C.N. Marine operates a coastal boat service in the area. Two coastal boats service Jackson's Arm and Sop's Arm stopping once a week going north and once a week going south from June 1 to December 31. These coastal boats deliver mail, food and other supplies as well as passengers.

There is a high density of passenger traffic in the area. With the completion of the Bay D'Espoir Highway the need for a marine passenger service has decreased in that area and it is possible that in a couple of years C.N. may transfer its high-speed passenger boats from the South Coast to this area.

iii. Air

An airport with landing facilities for jets and small aircraft is located in Deer Lake as well as 2 or 3 companies which offer helicopter services.

E.P.A. operates daily flights connecting Deer Lake with other areas of the province and Eastern Canada. No regular air transportation service operates between the Jackson's Arm/Sop's Arm area and Deer Lake. Helicopters and seaplanes service these communities as the demand arises and on a charter basis.

4. IMPACTS

4.1 Impacts on Climate

The creation of a 5300 ha reservoir in the Cat Arm watershed will likely have little effect on the climate of the region, but will have some local effect on the microclimate of the reservoir site. The maximum summer temperatures of the area will probably be reduced, because the water will not warm as quickly as the land. Freeze-up will probably be delayed slightly because the water will retain heat longer. After freeze-up, temperatures in the area will return to traditional levels.

Humidity and evapotranspiration rates will change very little, because the high water table throughout the area is almost as effective a source of evaporation as the reservoir. Precipitation and rates of precipitation should not change in the area.

Direction and speed of wind will not be altered by the creation of the reservoir, because at present vegetation in exposed areas is low and provides little resistance to the wind. There will be an increase in wind fetch distance, and a subsequent increase in wave heights can be expected along the more exposed shorelines. Sheltered areas in the valleys will be lost. The reservoir, when frozen, will provide a plain across which snow will blow, shifting some snow drifts from the western edge of the reservoir to the eastern edge. Sno drifts will develop along and invade the Woodlands in the eastern section. Increased sno depth will restrict movements by Wildlife, and cause breakage and deformation of tree saplings and seedlings.

4.2 Impacts on Geology

The major impacts on the geology of the proposed Cat Arm Development area will be associated with the removal of surficial and subsurface materials during the construction of site facilities, creation of the reservoir, and the construction of a permanent access road.

As mentioned in Section 2.3.3, an estimated 355,000 m^3 of impervious glacial till and 610,000 m^3 of sand and gravel will be required during construction of the proposed Development. Surficial glacial deposits within the Development such as eskers and ablation moraine, provide a source of these materials. The primary impacts associated with removal of surficial deposits include changes in geomorphology and changes in local drainage patterns which commonly induce erosion.

Three of the largest potential borrow areas are located in the valley of the Coney Arm River, along and under the riverbed. These areas were deleted from consideration as removal of material would most certainly jeopardize the Atlantic salmon population in the river. Other areas which were similarly deleted were located in Little Coney Arm near the beach, and on a beach just north of Devil Cove.

The major concentration of borrow areas, apart from those close to the main access road, are located in the northwest arm of the future reservoir and along the Cat Arm River below the main dam site.

The borrow sites near the Cat Arm River have the greatest potential for environmental disturbance however, much of the material will be taken from these sites during the time when the main dam is being constructed which in itself will cause increased sediment loading in the river. The removal of borrow material from these areas will have only an incremental effect on the river.

Post-construction borrow pit rehabilitation practices will reduce the asthetic impacts of these pits and in the long-term encourage geologic and biotic stabilization of the disturbed areas.

Within the reservoir there will be loss of floodplain and alluvial sites due to flooding. These will re-develop only slowly, at the higher flood elevations and will be under the influence of seasonally varying drawdown regime and greater wind(wave) exposure. The lack of sediment transport in inlet streams precludes formation of delta deposits.

The combination of seasonal runoff and demand-related drawdown for power generation will produce an unnaturally broad shore zone ranging from about 391 m (1290 ft FSL) to 384 m (1266 ft LSL). Different parts of this zone will be exposed for different lengths of time, and in a sequence that will vary seasonally. The lower portion of the drawdown zone will be exposed, usually only in late winter when the reservoir is ice covered. Most shoreline development, and the "normal" new shoreline of the reservoir will occur in the upper drawdown zone. The Cat Arm Reservoir shoreline will occur predominantly on bedrock or coarse boulder till. The major effect of shoreline wave and ice action will be to wash and scour surficial deposits such as organic matter and soil pockets from these resistant materials.

Vehicular movements, both inside and outside the reservoir zone, may lead to concentration of seepage water, especially on slopes, and result in erosion of the surface organic material.

No known mineral deposits will be flooded by the reservoir nor rendered inaccessible by any portion of the proposed Development. Construction of a permanent access road provides increased access for future mineral exploration and development. The lack of known mineral deposits does not allow for the quantification of the increase value to mineral resource potential.

4.3 Impacts on Forestry

The forestry resources of the Cat Arm area are not of current commercial interest due to lack of access (Hunter, 1980). The economic feasibility of harvesting much of this wood is limited, especially as it is located in scattered pockets of difficult to traverse terrain, and is of low quality. Stands of merchantable densities within the future reservoir area have been estimated by Hunter (1980) at 220,000 m^3 or 91,000 cords. These cover about 1700 ha of land or approximately 31 percent of the future reservoir area.

The construction of access roads to the proposed Development site will increase the potential for forestry utilization in the Cat Arm area. Creation of the reservoir will limit utilization of those forestry resources within the flood zone to the time period preceeding flooding. A reservoir preparation strategy has been developed which would allow for the present value of timber resources to be realized.

4.4 Impact on the Aquatic Environment

4.4.1 Reservoir Zone Impacts

A. Morphometry and Hydrology

The filling and operation of the proposed Cat Arm Reservoir will cause a number of physical changes in the present water system of ponds and tributaries. These changes include:

1. Increased water surface area from 12.4 sq. km to about 55 sq. km.

2. Increased maximum depth from 15 m to about 60 m.

3. Decreased shoreline length from about 185 km. to about 170 km at full supply level and about 175 km at low supply level.

4. Decreased flushing rate and increased residence time from 1 to 3 days to about 2 years.

5. A seasonal drawdown regime and average reservoir level that is concentrated on a different part of the littoral zone from year to year depending on long term precipitation and runoff conditions.

Table 34 describes the morphometry and hydrology of the future reservoir and forebay.

Table 34

Some important parameters describing the future reservoir (FSL 393 m)

	Cat Arm Lake	All Lakes	Future Reservoir FSL	Forebay FSL
Surface Area (ha)	112	1140	5814	326
Maximum Depth (m)	15		62	11+
Mean Depth (m)	5	5-	15	6.1
Volume (million m^3)	5.5		897	19.8
Live Storage (million m^3)			365	
Maximum Drawdown (m)	1-2		7.3	8.5
Mean Annual Drawdown (m)			1.7	2.7
Mean Elevation (m)	350		391.5	390.5
Runoff Yield ($m^3/s/km^2$)	0.042	0.042	0.042	0.04
Drainage basin (km^2)	632.5		650.6	650.6
Mean flow (m^3/s)	26.3		26.7	24.5
Flushing Rate (days)	2.4		389	30
Total Dissolved Solids (mg/l)	50	55	55(est)	55(es
Morphoedaphic Index (MEI)	10.0		3.6	9.0
Fetch Distance (km)	1		5	
Fetch Direction	ENE-WSW		SE-NW	

SOURCE: Beak, 1980

The present lakes are very shallow and considerable water moves through them relative to their volume so that no thermal stratification occurs and oxygen concentrations are at saturation. In the future reservoir, thermal stratification will occur early in the summer (late June) and will probably reach a depth of 10-20 m by late August. The separation of the warm epilimnion from the cold hypolimnion in the summer has implications for water quality which are discussed in the next section. The discharge through the forebay will be large relative to the volume and thermal stratification is not expected to occur in this body of water.

The periodicity of flows into and out of the reservoir will be relatively natural with peak discharges entering the reservoir in the spring, causing flooding of the littoral zone at that time, with a steady outflow of water occurring throughout the remainder of the year. In the forebay however, flushing will occur at a constant rate which is unnatural for temperate lakes.

The greater volumes of water in the reservoir and forebay will delay the annual thermal cycle. Ice cover will remain longer into the spring and will form later in the fall. The maximum water temperature that will occur in the reservoir will be less than the maximum temperatures reached in the small ponds.

The greater dimensions of the reservoir will result in the wind having more impact on the reservoir. The fetch will increase from a maximum of about 1 km in the present ponds to 5 km in the reservoir. Wind-induced circulation of surface waters will be deeper and erosion of the shorelines due to wave action will be more significant.

The great volume of the reservoir relative to the flushing rate will promote the settling of eroded particles in the reservoir. Soft sediments (sand and silt) will be more prevalent in the reservoir than in the lakes.

Draw-down of the reservoir will have some impact on all the physical parameters of the reservoir and forebay. The most significant impact will be that of wave-induced erosion on the draw-down zone. There will be a tendency for the draw-down zone to be swept clean of erodable organic and inorganic particles which will be deposited below the minimum water elevation. In the reservoir this elevation will be below 392 m. Draw-down is not expected to greatly affect the formation of the epilimnion in the summer. The epilimnion will develop as draw-down occurs and the maximum depth of the epilimnion will be considerably greater than the maximum draw-down.

B. Water Quality

The established pattern for changes in water quality in temperate reservoirs is described by Airphoto/Beak (1976). Flooding of the terrestrial environment leads to the rapid leaching of organic and inorganic nutrients from soils and rocks which produces a trophic surge lasting for a few years after flooding. After that, there is a trophic depression as nutrients from inundated soils and vegetation become exhausted or covered by a layer of silt which prevents further exchange. Ultimately, the reservoir may be less fertile than the lakes it replaces.

In Newfoundland and Labrador reservoirs, the trophic surge tends to be relatively small. No great increase in dissolved solids content has been observed in the Churchill Falls Reservoir. Fisheries and Oceans (1972 MS) compared the baseline nutrient conditions of the Victoria Lake Reservoir between 1965 and 1972 and concluded that the large scale increases in water fertility normally associated with reservoir formation in more southern latitudes had not occurred at that time in reservoirs of the Bay D'Espoir Development.

Airphoto/Beak (1976) discussed the long-term fertility of the Cat Arm Reservoir and concluded that it would be slightly less than that of the present lakes. A greater percentage of the precipitation falling on the watershed will fall directly onto the surface of the reservoir thus, water currently leaching organic materials and inorganic ions from the terrestrial portion of the watershed will no longer do so consequently, the ionic contents of the new reservoir are expected to be slightly less than present.

Airphoto/Beak (1976) predicted a decline in water colour due to the greater retention time of water in the reservoir. This will increase the depth of the euphotic zone.

MacLaren (1978) modeled the future reservoir for temperature and oxygen and concluded that, during the first five years of the new reservoir in summer months when water levels will be near maximum and possibly during winter when the reservoir is ice ocvered, there is a potential for a dissolved oxygen deficit in the hypolimnion of the new reservoir. While low oxygen concentrations can be lethal for certain organisms including brook trout, experience in other reservoirs has shown that flooding of undistrubed terrestrial vegetation has not resulted in the lowering of water quality. Bioassays conducted by Beak (1977) for the Wreck Cove Hydroelectric Project on Cape Breton Island indicated that decomposing peat did not produce substances toxic to rainbow trout.

The widespread disturbance of the reservoir floor by machine clearing activities and burning could well have a greater impact on reservoir water chemistry than flooding of natural vegetation. Machine clearing and bulldozer activities will disturb and expose remnants of the mineral horizons of the reservoir's largely podzolic solid profiles. After flooding, the soil and debris will become the reservoir substrates and participate in interstitial substrate-water reactions. These reactions could result in toxic levels of heavy metals such as iron and manganese at the benthic interface. Bruce and Spencer (1979) have suggested that the flooding of new reservoirs leaches mercury from the ground at a faster rate than natural historical weathering processes. This leads to a short-term elevation of mercury concentrations in reservoir fish. Burning of vegetation will result in the release of organic complexed elements. Some elements such as carbon and nitrogen will be volatilized and lost to the atmosphere. Other elements such as potassium, phosphorus, calcium and magnesium remain as ash and can either be complexed again, wind eroded, leached away or simply remain as ash to interact with the water column. The potential for impact is greatest during reservoir filling when these, as well as other mineralized elements, will quickly solubilize and enter the water column. The pH of the water might increase initially with formation of potassium hydroxide, calcium hydroxide and magnesium hydroxide, but should decrease gradually through buffering action of the reservoir and surrounding soils.

C. Biolimnology

The principal impact of the project on plankton communities in the reservoir will result from the decrease in flushing rates. This will allow the development of a greater standing stock of phytoplankton and zooplankton. No change in the species composition is expected at least with regard to the dominant species. Littoral species will probably not occur although they will still be present in the reservoir. A high flushing rate in the forebay will suppress the development of a plankton community in this water body however, large quantities of plankton will be flushed into the forebay from the reservoir.

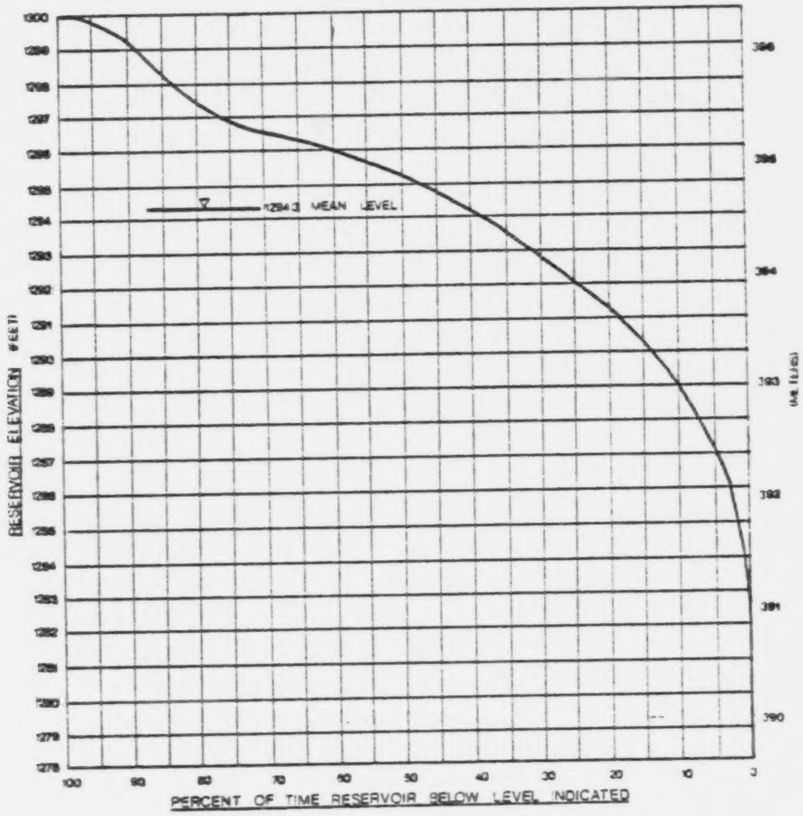
The trophic surge during the first three or four years may result in a twofold or threefold increase in phytoplankton biomass. A bloom of rotifers may also occur. An increase in primary production will be of some benefit in terms of an increase in secondary productivity, however historical data for Labrador reservoirs indicate an increase in productivity for a period of 5 or 7 years followed by a decrease.

Littoral benthic invertebrates, particularly insects, are the most significant link in the food chain to brook trout and hence it is appropriate to consider the impact of reservoir creation on this component of the aquatic community. In the Airphoto/Beak report, the impact of the proposed draw-down on benthos was identified as the major limiting factor for trout production in the future reservoir. That prediction was made based on an engineering design with a maximum draw-down of 18.5 m. Since then, the design has changed so that the maximum draw-down will be only 7.3 m. The impact of draw-down on the littoral benthos will depend on the timing, frequency, extent and duration of draw-down. These parameters were studied in detail using monthly storage depletion values simulated for the period 1929 to 1979 by Shawmont as part of the Cat Arm River Regulation Study. Generally the timing of reservoir fluctuation follows a natural pattern with highest elevations occurring during the spring and lowest elevations occurring in late winter. Elevations become stable for one or two months during the fall rains. The mean elevation of the reservoir will be 391.5 m (Figure 29). Over the 50 year period investigated, there were only seven years when the reservoir did not reach the FSL (393.2 m) in May or June, and during one of these years it did not exceed 389.8 m. During the same period, the reservoir reached LSL (385.9 m) once. The lowest annual elevation usually occurred in March or April. The average annual change in elevation was 4.5 m, with a range from as little as 1.8 m to a maximum of 8.8 m. Maximum changes in elevation or water level in the present lakes are probably in the order of 1 m.

FIGURE 29

CAT ARM RESERVOIR LEVEL DURATION CURVE

(BASED ON RESULTS OF REGULATION STUDY CARRIED OUT IN PRE-FEASIBILITY STUDY, FROM SHAWMONT)



SOURCE: Shawmont, 1980

The rate of change of water elevation was also studied. The average decline in elevation during the summer, fall and winter was 1.2 cm/day and the maximum was 2.4 cm/day. During the spring, the average increase in water elevation was much greater, averaging 6.7 cm/day with a maximum of 13.2 cm/day. These rates of change are probably much less than presently occur in the lakes.

Studies conducted by Beak (1977) for the Wreck Cove Hydroelectric Project on Cape Breton Island indicated that in small lakes similar to those in the study area, most of the littoral benthos was concentrated within 2 m of depth around the shoreline. In larger lakes, this zone might be expected to increase in depth because of deeper wind-induced surface currents and deeper euphotic zones. While the extent of draw-down at Cat Arm may well exceed the critical 2 m+ depth where productivity of the benthos is greatest, it is expected that the relatively slow rate of draw-down will allow some epibenthic invertebrates to adjust to the change in water level and even the more sessile components such as the sphaerid clams and oligochaetes may be able to adapt to this rate of change. The benthic invertebrates are primarily detrivors and the reflooding of the upper draw-down zone each spring may promote their productivity by exposing them to an extensive allocthonous food supply of terrestrial origin. The eggs of most aquatic invertebrates are laid during the summer and they hatch immediately. The juvenile stages, which will appear in mid to late summer, will be able to react to continuing draw-down through the fall and winter until the spring flood.

It is thus probable that a major component of the littoral benthos will be able to survive and adapt to draw-downs of the magnitude and the rate produced by the operating policy of this project at least during some years.

Draw-down during some years will be considerably worse than in others. This may aggravate wide fluctuations in year class strength in the trout population because of its impact on the benthic community.

The overall productivity of the benthos in the reservoir is expected to be less than that in the lakes because the flushing rate will decline significantly and the nutrient content will be less.

Water level fluctuations in the forebay will follow those in the reservoir but will be slightly more extreme. A high constant discharge to the forebay from the reservoir will introduce large quantities of plankton and seston which will stimulate the productivity of the benthic invertebrates that adapt to the large draw-down.

D. Fish

i. Potential yield of brook trout from the future reservoir and forebay

The most obvious impact of the proposed Development project on the fish resource is the conversion of large quantities of the terrestrial environment to the aquatic environment by reservoir flooding. The combined surface areas of the reservoir and forebay will be six times greater than the combined surface area of all the lakes and ponds. The potential productivity of the reservoir and forebay, however, will be less than that of the smaller lakes and ponds, even if the project does not introduce any special limiting factors. Nevertheless, the net effect will probably be an increase in fish numbers within the project area. Brook trout are essentially a shallow-water, bottom feeding species which will be most abundant around the perimeter of the reservoir. The large volumes of water in the pelagic and profundal zones will not be utilized to any great extent by this species. The relative differences in the basic productivities of large and small water bodies is expressed in the morphoedaphic index (MEI). A first order approximation of potential yields to a sport fishery, assuming light exploitation, can be estimated for the reservoir as they were for the lakes from the MEI (Ryder 1965). These potential yield estimates are only rough approximations. The potential yield from the reservoir would be 1.8 kg/ha/yr compared to 3.1 kg/ha/yr for Cat Arm Lake. If the potential yields from all the small lakes and ponds are similar to those for Cat Arm Lake, a comparison of the total potential yield from all the lakes can be made with the total potential yield of the future reservoir. The total potential yield from the reservoir is 10,600 kg/year and from the existing lakes it is 3500 kg/year thus, if no serious limiting factors are introduced by the project, the future reservoir will have a potential yield to a sport fishery about three times that of the present lakes.

Because the reservoir presents a large increase in habitat area, a shift in the size composition of trout may be expected towards larger fish. Fisheries and Oceans (1971) suggested that this might be the cause of an increase in growth rate of ouananiche after creation of the Bay D'Espoir Reservoir. Longevity of brook trout may also increase.

The potential yield of the forebay was not calculated because the flushing rate is not natural. It is expected that the constant high rate of discharge will introduce large quantities of plankton and other drift from the reservoir, and terrestrial drift from the forebay canal. The productivity of trout is expected to be higher than average in the forebay and in the small pond at the head of the forebay tunnel.

ii. Impact of reservoir creation and operation on brook trout spawning

Creation of the reservoir will flood all the streams presently linking the lake system, resulting in a loss of 2200 units of Type 2 rearing habitat (Table 7, Figure 16). Four major tributary streams have the potential to provide 5400 units of Type 2 habitat and 200 units of Type 1 habitat (Figures 17 and 18) and there would be some additional habitat available in smaller streams which were not surveyed. There are three grade B barriers on Tributary T5 which could limit access to 1200 units of Type 2 habitat and 60 units of Type 1 habitat and these barriers should be studied in more detail. The major tributaries are estimated to have a standing stock of juveniles brook trout in the order of 56,000 fish. The potential recruitment from this standing stock to the future reservoir is not known and it is possible that the potential yield of the reservoir will not be realized because of low recruitment rates from the streams.

Lake spawning of brook trout is suspected to be of some significance in the lakes and the future reservoir will have many rock shoals that could be so utilized if draw-down is not limiting. Brook trout normally spawn in shallow water. The average draw-down during September to April will be about 2.4 m and range from 0.9 - 3.7 m. The mean reservoir elevation for September is 391.7 m. If ice thickness does not exceed 1 m in depth, brook trout which spawn at 3 m in September (at approximately elevation 388.7 m) would have their eggs covered by at least 0.3 m of water 44% of the years. Trout spawning at 1 m of depth or elevation 390.7 m in September would have their eggs remain underwater only 4% of the years. It is not known if brook trout are capable of adapting to this situation. It has been observed that salmonids such as lake trout and whitefish will utilize deeper shoals in larger lakes and this is believed to be because wind-induced surface currents are deeper in large lakes, thus water circulation and constant oxygenation of the eggs occurs at greater depths. Of course, at Cat Arm, the reservoir will have an ice cover during much of the incubation period.

The dam will eliminate any access by trout to the lower Cat Arm River but this river is not believed to be utilized at this time because of barriers.

Recruitment of juvenile trout to the forebay is likely to be quite limited. The tributary streams entering the future forebay were not studied in detail and were only observed from the air, but they appeared to be very small and to have steep gradients. Draw-down in the forebay will be slightly greater than in the reservoir and the impact on forebay spanwing will be somewhat worse. Entrainment of trout from the reservoir via the forebay canal and tunnel may provide a source of fish.

iii. Impact of reservoir deoxygenation

MacLaren (1978) predicted that dissolved oxygen deficits (concentrations 4 mg/l) could occur in the new reservoir during the first five years. Their conclusions imply that this deoxygenation would be restricted to deeper areas (hypolimnion) in the reservoir but their graphs suggest that it could also occur in the epilimnion during the summer. Brook trout would probably survive deoxygenation of the hypolimnion with little problem since they are shallow-water littoral fish and temperatures will not get high enough in the epilimnion during the summer to drive them below the thermocline. Deoxygenation of the surface waters during the summer would have a catastrophic impact on brook trout and their prey species over the five year period but they would probably recolonize the reservoir from refugia in the streams at the end of that period.

The impact of reservoir deoxygenation on the water quality of riparian releases and of the forebay is not certain. Any water released to the Cat Arm

River would probably become rapidly reoxygenated because of the steep gradients and many rapids and waterfalls. This process might not be as thorough in the forebay canal and tunnel. Deoxygenation is not expected to produce toxic organic substances through the anaerobic decomposition of vegetation and organic soils.

iv. Impact of reservoir clearing

Brook trout are expected to survive in the reservoir whether it is cleared of trees or not. Flooding forest has not appeared to have adversely affected salmonids in either the Churchill Falls Reservoir or the Bay D'Espoir Reservoir. Dead trees in the shallow littoral zone provide substrates for benthic invertebrates and cover for juvenile trout. Not clearing the forest will delay establishment of the new shoreline and will inhibit the erosion of organics from potential spawning shoals at the 388 m elevation.

The greatest impact of not clearing the reservoir will be on the utilization of the brook trout as a sport fishery resource. It is difficult to operate a boat or angle in a reservoir that is full of trees nevertheless sport fishing does occur on both the Churchill Falls Reservoir and Bay D'Espoir Reservoir. The focus of any sport fishery is expected to be at the forebay which will be cleared, and at access points along the north-east shore of the reservoir (Figure 16). The whole problem of reservoir preparation is discussed in detail by Hunter and Associates (1980).

v. Impact of entrainment

Current velocities in the forebay canal leading to the forebay tunnel (Figure 2) and in the power canal leading out of the forebay to the generating station intake will average 0.21 m/s and reach a maximum of 0.58 m/s. Brook trout will be able to avoid entrainment into these structures by swimming against the current but should they enter into them for any distance, it will be difficult for them to escape because of a lack of resting places. Current velocities in the forebay tunnel will be higher, averaging 0.74 m/s, and reaching a maximum of 1.16 m/s. The latter velocity could actually result in the passive entrainment of trout into the tunnel.

Trout entrained into the forebay have the option of taking up residence in the small pond between the canal and forebay tunnel, and those entrained into the forebay tunnel can take up residence in the forebay. Fish entrained into the power canal will presumably be impinged at the trash racks in the intake or will pass directly through the turbine.

The problem of entrainment is not expected to be too serious because there is no behavioural stimulus, such as a migration urge, for the trout to enter these structures. Trout are likely to congregate at the intake of these structures to take advantage of the currents induced in the reservoir and forebay and occasionally some of them will probably be entrained.

vi. Impact of the project on the sport fishery

A major factor preventing the establishment of any sport fishery in the area at this time is the lack of access which will be overcome after the project. The sport fishery is not expected to be heavily exploited because of its low quality relative to other sport fisheries in the province and its relative remoteness from major population centers.

4.4.2 Downstream Impacts

A. Cat Arm River

Construction of the main dam on the Cat Arm River will divert the whole flow of the drainage basin located on the plateau (26.3 m^3/s) away from the Cat Arm River and into the generating station at Devil Cove. The amount of flow remaining in the river after the project will increase gradually from nil below the dam to the total accumulation from all the downstream tributaries at Great Cat Arm. The basin drained by the tributaries below the dam is not large and is estimated to be 148 km^2. Using yield factors for runoff calculated by Shawmont (1980) (0.0416 m^3/s), the mean discharge from the area below the dam at Great Cat Arm will be 6.2 m^3/s after the project. This will be about 19% of the mean discharge presently occuring at Great Cat Arm. The percent recovery of flow would be progressively worse as up river towards the dam.

Reference to Table 35 indicates that flows below the dam on the Cat Arm River will be less than those recommended by Tennant (1975) necessary to protect salmonid spawning and rearing habitat. Reduction in flows of this magnitude will cause severe degradation of salmonid habitat. It is estimated that 3800 units of Type 1 rearing habitat and 1900 units of Type 2 rearing habitat will be lost due to flow reduction in the section of the Cat Arm River between the dam and the first major obstruction at the river mouth. This will result in a virtually complete loss of resident brook trout within this stretch of the river.

Table 35

A comparison of Tennants' (1975) suggested flows (m^3/s to expected flows in the Cat Arm River at Great Cat Arm.

	Tennant's Criteria at Great Cat Arm			Future Flow at Great Cat Arm		Reparian Flow at Great Cat Arm	
	High Protection	Moderate Protection	Instantaneous Minimum	Mean Flow	Instantaneous Low Flow	High Protection	Moderate Protection
Summer (April to Sept)	60% - 19.5	40%-13.0	10%-3.3	8.9	0.3	10.6	4.1
Winter (Oct to March)	40% - 13.0	20%-6.5	10%-3.3	3.7	1.2	9.3	2.8

Firm Discharge of the G.S. = $21.3 m^3/s$

Maximum Discharge of the G.S. = $39.4 m^3/s$

Average Secondary Flow = $3.2 m^3/s$

Average Spill = $2.3 m^3/s$

Mean discharge of the Cat Arm River at Cat Arm = $32.5 m^3/s$

SOURCE: Beak, 1980

Population estimates for the Cat Arm River were particularly difficult to obtain due to high water flows at time of sampling, however the implications of this loss of brook trout population can be extrapolated from existing knowledge of the habitat. Beak (1980) reports that the Cat Arm River below the proposed dam site is unlikely to contribute to recruitment of trout into the headwater lake system due to the presence of major barriers and steep gradients throughout the river, especially the major type B barrier at the outlet of Cat Arm Lake.

The reduction of discharge will probably reduce runs of Atlantic Salmon and anadromous brook trout in the Cat Arm River. A run of sea-run trout (200-300 fish) is believed to utilize spawning habitat in the Cat Arm River estuary. To gain a better appreciation of the impacts on this run and potential mitigation opportunities a second fisheries study is presently underway.

As such, dewatering the Cat Arm River will result in virtually a complete loss of resident brook trout in the Cat Arm River below the Main Dam.

Reduced river flow will also result in a localized decrease in productivity of fish which feed in the Arm because of decreased plankton productivity. If any remain both marine species and the young, of brook trout, and salmon smolt present after diversion will be affected. However, changes in plankton productivity will likely be small and the changes in fish productivity minor. The abundance of benthic feeders in the wholly marine fish fauna will probably increase as the abundance of infaunal benthic invertebrates at the head of Great Cat Arm increases. Because the changes induced by changes in productivity will likely be small, they are not considered a major impact.

Reduction in Cat Arm River flows will likely result in a small reduction in water column productivity (zooplankton and phytoplankton) in the estuary, particularly at the head. This is because freshwater contains some essential plant nutrients (chiefly nitrate) and also because the mixing of fresh and saltwater drives a return circulation of nutrients, both regenerated on the bottom of the Arm and from White Bay, and hastens mixing of nutrients upward in the water column. The contribution from White Bay is likely to be most important to productivity in Great Cat Arm in the spring when nutrient levels are highest. Changed water column productivity is not considered to be a major negative impact.

No major impacts of the diversion are predicted for Great Cat Arm macroalgae. The abundances and diversity of species now present will probably increase, but will probably be lower near the head than in the outer Arm. This is in part because of low concentrations of nutrients in the water column during summer. The future freshwater regime will probably prevent the extension to the head of the estuary of species which cannot tolerate low salinities.

No negative impacts are foreseen for benthic invertebrates. As with the macroalgae, the abundance and diversity of species is expected to increase. More species with narrow ranges of salinity tolerance are expected in the intertidal zone. Because the macroalgae regime will still be limited, abundances of grazers such as the sea urchin probably will not change. The only major change will be an increase in the abundance of infaunal benthic invertebrates as organic loading of the bottom by river inflow decreases.

B. Devil Cove Tributary and Eastern Diversion Tributary

The mean annual discharge of the Devil Cove Tributary is estimated to be 0.8 m^3/s (MacLaren 1978) and diversion of the headwaters in the forebay area will reduce the catchment area by 8.5 km^2 and the mean discharge by 0.3 m^3/s or about 38%. Construction activities in the valley and construction of the generation station at Devil Cove will have further impacts on this small stream. The stream is assumed to contain brook trout through its length but the population has no resource value. The accessible section of stream at Devil Cove may contribute juveniles to an anadromous brook trout run. There are roughly 3 units of rearing habitat accessible to Devil Cove and the standing stock of brook trout in it would be about 25 fish (300 g).

The major negative biological impact of the increased freshwater flow into Devil Cove will be the loss of much of the intertidal and immediate subtidal marine biota. Only a few species which can stand continued exposure to dilute seawater will survive, and these will be less abundant and probably stunted, as a reaction to reduced salinity. Reductions in light levels at the bottom, caused by the likely high humic content of the discharged water, will result in a deterioration of subtidal plant life in the Cove and will eventually lead to a move to shallower water of deeper macroalgae (i.e., Agarum cribrosum). Reduced plant growth in Devil Cove will lead to decreased abundance of sea urchins (which feed on the plants), and sea stars (which feed on urchins). The effect of the freshwater outflow on the intertidal biota of the shoreline of White Bay to the south of Devil Cove will be relatively minor as the freshwater layer will be mixed quickly with seawater. It is likely that the layer of reduced salinity water will not extend farther than 1 km south of Devil Cove and that significant reductions in subtidal fauna and flora will probably only occur adjacent to the Cove.

It is unlikely that the impact on the intertidal and sublittoral biota of Devil Cove might be alleviated by including freshwater-seawater mixing in the design of the powerhouse and tailrace. This alternative would lead to further reductions in the subtidal biota, which is not freshwater tolerant, and it is conceivable that only with almost complete dilution of the freshwater would the intertidal biota be unaffected.

Productivity of phytoplankton will probably increase as a result of increased nutrient input. Zooplankton productivity will likewise probably increase. Localized increases in abundance of planktivorous fish may thus be expected. Benthic invertebrate species composition would probably not change as it is expected that water from the development will not contain the suspended particulates which appear to be responsible for low benthic biomasses in the head of Great Cat Arm. The effects, if any, on Atlantic salmon will be minimal. Some adults returning to the Cat Arm River may be attracted to Devil Cove if they miss the entrance to Great Cat Arm. The effect of freshwater flows emanating from Devil Cove is not expected to confuse salmon or otherwise deter them from homing on rivers further south in White Bay. The effect of the input will probably be comparable to that of existing rivers now entering the sea in the paths of salmon migration however, little is known of this aspect of salmon behaviour.

4.5 Impacts on Wildlife

The impacts of the proposed Cat Arm Development on terrestrial wildlife include: a) habitat loss and/or alteration; b) effects of improved access; c) effects of disturbance; d) effects of environmental contamination from waste disposal; accidental spills and siltation of streams; and e) direct mortality.

Loss or change in habitat and improved access are likely to have the greatest long-term effects. Disturbance and environmental contamination are expected to be short-term phenomena associated with the construction phase. Direct mortality to wildlife is likely to result from collision with vehicles, but is relatively insignificant since a very small number of animals are likely to be affected.

4.5.1 Caribou

Little caribou habitat will be lost in this development since most suitable habitat is above full supply level. Northland (1980) indicate that the reservoir area is either unsuitable for, or has moderate limitations to, use by caribou. Areas within the Cat Arm watershed which are most suitable for caribou (areas having no significant or very slight limitations) occur in the western portion of the watershed beyond the zone of flooding.

Calving activity of the Northern Peninsula caribou herd is not expected to be affected by the Cat Arm Development. Caribou are not known to calve within the proposed reservoir area. The nearest known calving range (Portland Creek), lies adjacent to but primarily outside the western boundary of the watershed. There are reports that calving also takes place south of Lake Michel, however this is not certain. In any case this region will be unaffected by the development.

No loss of caribou winter range is anticipated from the proposed development. Northland (1980) reports that the major wintering areas are entirely outside the Cat Arm watershed. Local residents indicated that small numbers of caribou winter on the uplands just west of Devil Cove, Little Coney Arm and Frenchman's Cove (Shawmont, 1980 b) however, the 1979-80 winter distribution surveys recorded limited activity there. In any case, these areas are outside the proposed reservoir area and would not experience physical deterioration or loss of range. Also, the access road and transmission line locations as proposed by Shawmont (1980b) are east of the three areas and they neither cross these winter ranges, nor restrict access by caribou to them.

Some negative impact would be expected to the Devil Cove and Little Coney Arm wintering areas if construction activities (road, reservoir development, etc.) continued through a winter in which caribou were present. Caribou would likely vacate these areas in favour of the location west of Frenchman's Cove or move to winter range farther west however, this displacement would probably be temporary.

At this time it is not possible to suggest what impact the Cat Arm Development will have on Northern Peninsula caribou post-calving and summer range. The delineation of such range is presently largely speculative because of apparent changing patterns of use (possibly related to snow cover) and a paucity of data on distribution during these seasons. Monthly monitoring of radio-tagged caribou provides some insight into seasonal range use, but surveys over a number of years are required if meaningful data are to be obtained.

No data are available on specific migration routes, however an airphoto interpretation exercise conducted by Northland (1980) indicates few caribou trails within the proposed reservoir area. One set of trails was located outside the reservoir area approximately 3.5 km northwest of the main dam and spillway in the general location of a sighting of 12-15 caribou by Shawmont personnel in September and October, 1979 (Shawmont, 1980b). Whether this indicates summer/fall range is not known. Based on all available information it is highly unlikely that caribou migration will be affected by the Developments.

The primary impact of the Cat Arm project on caribou is likely to result from increased access to the Cat Arm area and the plateau of the Long Range Mountains. The improved access will lead to heavier legal and illegal hunting pressure.

4.5.2 Moose

The magnitude of potential change in the proposed Development area is greatest for moose. The possible negative impacts fall into two broad categories:

1. Habitat loss
2. Increased access

Suitable winter range is an important element of good moose habitat. The forested valleys of the Cat Arm River and tributaries adequately meet this requirement and moose numbers are high. The Cat Arm watershed is at the centre of Moose Management Area No. 3 (Harbour Deep) which supported the second highest density of moose of the 36 management zones on the island in 1975, an estimated 2.61 moose per square mile (Strapp and Mercer, 1975). The distribution surveys conducted during this study indicated that numbers remain high.

Some important moose wintering areas, and possibly calving and summer habitat will be lost as a result of this Development. This will cause some increase in densities of moose in areas adjacent to the reservoirs, possibly resulting in an overbrowsing situation. It was in an attempt to avoid such a situation that Area 3 was opened for winter hunting in 1975. A hunter success rate of 75% was realized and 206 moose were taken (Strapp and Mercer, 1975).

The proposed development may result in a lowering of carrying capacity for the Cat Arm area generally. However, the increased access could result in greater hunting pressure and greater hunter success, thus stabilizing the situation after several hunting seasons. The improved access could also increase illegal hunting. The moose population should be monitored closely to detect signs of overharvest.

4.5.3 Black Bear

Present Black Bear populations in the reservoir site are not large. Filling of the reservoir will result in the displacement of individuals from foraging areas if flooding occurs during the non-hiberation period. If the reservoir is filled during the winter hibernation period, individuals wintering at low elevations may be lost. A decrease in regional and local Black Bear populations, therefore, will occur.

4.5.4 Furbearers

Terrestrial furbearer populations, i.e. red squirrel, pine marten, snowshoe hare, red fox, lynx and ermine will also decrease. Arctic hare populations should not be affected by the filling or operation of the reservoir since most suitable habitat occurs above Full Supply Level.

Local populations of red squirrel and snowshoe hare will decrease with loss of habitat, i.e. coniferous woodland. Likewise, local populations of predator species (pine marten, red fox and Canada lynx) will decrease because of loss of habitat in the reservoir and reduction of prey species such as red squirrel, snowshoe hare and meadow vole.

Impacts on aquatic and semi-aquatic furbearers will occur during filling and operation of the reservoir. Filling of the reservoir will cause displacement of individuals with flooding of dwellings (i.e. Beaver and Muskrat lodges and bank dens), as well as loss of habitat. The operation of the reservoir with fluctiations in water levels will impact on aquatic furbearers by maintaining low population numbers and/or by causing die-offs during winter months when animals are isolated from food caches due to low water levels. The reservoir will negatively impact the present low numbers of aquatic furbearers, reducing populations and possibly permanently displacing these animals to areas adjacent to the Development.

4.5.5 Birds

Impacts will occur on the bird populations of the proposed reservoir, but they should be insignificant to regional populations. The local reservoir bird populations will be affected in the following ways:

1. Loss of island and riverbank nesting habitat for Canada Geese and Common Merganser;
2. Loss of numerous ponds and small lakes will eliminate nesting habitat for Black Duck; Greenwinged Teal, Ring-necked Duck and Common Loon;
3. Loss of shorebird nesting sites on delta islands, rocky lakes and river shores;
4. Loss of nesting, migration and wintering habitat for Passerines, especially Warblers and Finches;
5. Loss of Herb/Moss Wetlands will destroy nesting sites of Greater Yellowlegs and Least Sandpiper;
6. Loss of feeding areas for Goslings and Ducklings in the littoral zone;
7. Loss of wintering habitat for Rock and Willow Ptarmigan;
8. Loss of small mammal and other prey species for birds of prey, i.e. Owls, Hawks, Eagles and Osprey; and
9. Increased water surface area may encourage Canada Geese and other waterfowl species to use the reservoir as a migration staging area.

Most negative impacts will be absorbed by the remaining communities throughout the ecological development of the reservoir, but this process will be slow. Of overall importance will be a decrease in numbers and diversity of bird species in the area.

4.6 Impacts on the Human Environment

4.6.1 Impact on Labour Force, Employment and Income

A. Direct Employment

The net direct employment of contractors' work force and field engineering staff is expected to total 1,280.7 man-years over the 43 month construction schedule with 968.3 man-years (76.6%) occurring within a peak 28 month period. The schedule for the contractors' work force is shown in Figure 4.

The impact on the Provincial labour force will be small but positive. The size of the Provincial labour force as of April, 1980 was 202,000 of which 170,000 were employed. Peak employment in 1982 and 1983 of 600 represents only 0.3% of the total labour force and 0.35% of those currently employed. The impact on the provincial construction labour force will be more significant with peak employment representing 3% of the 20,000 in the construction trades in 1979.

The impact on Provincial labour income will also be small. Total labour income over the life of the development is estimated to be $32.217 million or 0.28% of the total provincial wages and salaries for the same period (Table 36).

Table 36

IMPACT OF DEVELOPMENT ON PROVINCIAL LABOUR INCOME

	1981	1982	1983	1984	Total
Man-Years[1]	95.6	472.2	524.9	188.0	1280.7
a) Contractors Work Force	71.5	410.0	455.6	145.7	1082.8
b) Field Engineering Staff	24.1	62.2	69.3	42.3	197.9
Average Weekly Earnings[2]					
a) In Construction[3]	$ 415.86	449.13	485.06	523.36	
b) For Field Engineering Staff[4]	$ 480.77	519.23	560.77	565.77	
Average Annual Income					
a) In Construction	$21,625.	23,355.	25,223.	27,241	
b) For Field Engineering Staff	$25,000.	27,000.	29,160	31,493	
Total Direct Labour Income ($m)	$ 2.148	11.255	13.513	5.301	32.217
a) Contractors Work Force	$ 1.546	9.576	11.492	3.969	26.583
b) Field Engineering Staff	$ .602	1.679	2.021	1.332	5.634
Provincial Wages and Salaries and SLI ($m)[5]	$ 2,489.	2,713.	2,957.	3,223.	11,382
Total Direct Labour Income as Percentage of Provincial Wages and Salaries	0.036%	0.415%	0.457%	0.164%	0.293

[1] As per Shawmont Feasibility Report, Cat Arm Development, 1980

[2] Assumed to escalate 8% per annum

[3] Based on actual weekly earnings in 1979 of $356.53

[4] pers. comm. Shawmont, 1980

[5] Based on actual wages and salaries and selected labour indices (SLI) in 1979 of $2095 million with an assumed escalation of 9% per annum.

SOURCE: Saga (1980)

While the impact of direct labour on the provincial labour force will not be significant, the impact in the study area will be more substantial. It is anticipated that only a small percentage of the labour force will come from the immediate study area of Jackson's Arm and Sop's Arm. There are numerous factors causing this. The fishery is developing very rapidly in this area. Major expansions of the fish plants in Jackson's Arm will be straining the available labour force in the community and surrounding area during the May to December fishing season. H. B. Nickerson and Sons Ltd. will be increasing its number of hourly paid employees to 180 during peak production periods compared to approximately 40 in 1979. Also, additional people will be needed if the company proceeds with plans to process ground fish. Another small fish plant operator, Mr. Fradsham, expects to employ an additional 20 - 25 workers this year (Source: Provincial Fisheries, Field Office Port Saunders).

Bowaters Newfoundland Ltd. employs approximately ten loggers from Jackson's Arm, Pollard's Point and Sop's Arm, 50 from Hampden, 20 from Howley and 100 from Deer Lake in its logging camps. This is seasonal employment from January to March and from June until mid-November (Source: Bowaters Newfoundland Ltd., Woods Personnel, Corner Brook). Interest shown by some loggers in the area to work in the fish plants represents a desire to work closer to home. These woodsmen may also be interested in working on the Cat Arm Development.

The hydro development is not expected to draw a large portion of its required labour force from existing jobs in the Jackson's Arm/Sop's Arm area. The major expansion of the fish plants has helped to generate a feeling of permanence with regard to the fishery. Fishing in these communities has been a way of life for many years involving practically all family members. Baased on the seniority hiring system and 65% of the plant workers being female, it appears unlikely that many workers would leave the fish plants for jobs at the hydro development.

Assuming an average of 200 - 300 individuals employed at the two major fish plants and that a maximum of 50% of the male employees would leave to work at Cat Arm, 35 - 53 men would be lost from the fish plants. Wages for fish plant workers average $6.00/hr. compared to $7.90 for construction workers.

Few serious fishermen will halt fishing for a year or two to work at Cat Arm since monetary compensation for most fishermen in the area would not be as great as could be obtained from the fishery. In addition, they may have problems obtaining fishing licenses when returning to the fishery, especially crab fishermen who are required to catch a certain quota of crab each year to keep their licenses. Another deterrent is the regulation requiring a fisherman to derive 75% of his yearly income for a two year period from fishing to qualify for loans from the Fisheries Loan Board. One possible occurrence may be fishermen fishing from May to October and working at the Cat Arm Development from October to March. (Source: Provincial Fisheries, Field Office, Port Saunders).

The size of the local labour force that will be employed by the Cat Arm Hydro Development is difficult to estimate since current reliable statistics on the size and characteristics of the local labour force are not available. In addition, it is not possible to predict the economic conditions that might exist in three or four years. Although the future economy of the area looks bright, factors such as levels of fish quotas imposed by the government could have a substantial impact. Consequently, although it now appears that only a small portion of the work force will come from the closest communities of Jackson's Arm and Sop's Arm, this may change at the time of development.

Another source of labour may be the communities such as Westport on the other side of White Bay, or Englee which is further north. Individuals from these communities could commute by boat and have expressed an interest in working in the fish plants in Jackson's Arm (Source: Provincial Fisheries, Field Office, Port Saunders). There also appears to be a tendency for the offspring of residents in the area to return home if employment is available.

Deer Lake, Hampden and area should be able to provide a large number of woodsmen, heavy-equipment operators, carpenters and labourers that will be needed during the development. Workers from other hydro developments in the province such as Hinds Lake and individuals from other areas of the province will make up the balance of the work force however, a major portion of the Hinds Lake work force is expected to be employed at the Upper Salmon Development.

Based on the information gathered about the work force in the area Jackson's Arm and Sop's Arm are not expected to be a source of labour during the development. However, employment of workers in the remainder of the study area should reach a minimum of 300 in 1982 and 1983 representing 50% of expected peak employment for the whole development.

The impact on local labour income is not expected to be significant in Jackson's Arm and Sop's Arm. The greatest source of income in these two communities is expected to continue to be the fishery. The greatest impact will be on the other communities in the study area. The total labour income over the four year life of the development is estimated to be at least $13.29 million based on the assumption of a minimum 50% local work force. This would represent significant contribution to the labour income in the area.

The impact on the area of non-local labour income will not be significant. Most of the workers will be living in construction camps and it is expected that most of the income earned will either be spent outside the region when the workers return to their homes or by their families during the development. The exceptions will be the small number of employees who relocate within the area for the duration of the development.

B. Indirect Employment

Employment will result indirectly from purchases made by contractors within the regional economy and from expansion within the service sector of the area.

A moderate level of purchasing will occur in the area. These will consist of food, fuel and other camp and industrial supplies that are available. Fresh vegetables should be available from farmers in the Cormack area. The amount of industrial supplies that will be used will be limited because the basic structures (dam cores) will be constructed from readily available glacial till. The dollar value and type of expected purchases is not available and it is thus not possible to quantify the increase in employment due to these purchases other than to say that there will be some small increase.

The service sector will grow as a result of the development. The increase in population resulting from the development coupled with that resulting from the expansion of the fish plants will strain the existing school facilities at Jackson's Arm. To alleviate the overcrowding a new primary and elementary school may well have to be built, resulting in the creation of more construction jobs. Alternately, portable classrooms can be erected and several additional teachers hired.

Boarding house, motels, retail establishments and all other existing businesses will certainly experience increase activity. The Cat Arm Development combined with the fishery expansion may provide the incentive for expansion of existing businesses or the establishment of new ones in the area.

The level of community services may also increase. Medical services would improve with the possible addition of a doctor to the area. Transportation would improve with the upgrading of roads. Recreational facilities would grow as demand increases.

The spending habits of workers housed in construction camps differ from the spending habits of individuals earning the same income living in a community. Since workers in construction camps are provided with room and board, laundry and some sundries they have greater disposable income and can be expected to spend more in retail establishments, restaurants and on recreational activites. For example a local night club would benefit from increased patronage.

Some long term employment may result if the Cat Arm access roads remain open after the completion of the project. Access roads to the wilderness area may cause tourist activity to increase, as well as encourage woods clearing and logging operations. The construction camp water and sewer system could form the basis of summer cabin or tourist accommodation. Hunters and sports fishermen will be attracted to the area, although as noted the sports fishery is a poor resource in the area.

4.6.2 Impact on Tax Revenues and Gross Domestic Product

Direct labour income from the development will have a modest impact upon personal income tax revenues. It is not possible to accurately determine the amount of personal income tax that would result because of the number of factors that have to be taken into account in the calculation. A rough estimate of $8.3 million has been calculated assuming that personal income tax will account for 20% of total labour income.

Corporate income taxes resulting from the development are also expected to be small. It is not possible to quantify these taxes since it would require having knowledge of the corporate profits that would be generated as a result of this project.

The impact on Gross Domestic Product (GDP) is also insignificant. The GDP is $3,180 million (preliminary) and $3,537 million (forecast) for 1979 and 1980, respectively. The cash flow for 1982 (peak year of the development) is forecasted to be $79.6 million or 2.25% of 1980 GDP. Since most capital expenditures will be made outside the province, the actual contribution from the project in the peak year will be in the range of 0.5% to 1.0% of 1980 GDP.

4.6.3 Impacts on Population

The Cat Arm Hydro Development is not expected to cause a significant increase in the resident population due to the short term nature of the construction however, as stated earlier in this report, there has been an interest shown by former residents to return to these communities. The development should cause this interest to increase however, only six permanent positions will be created since the Cat Arm Development will be operated by remote control. Thus any significant number of new residents in the area will not be a direct result of this development.

4.6.4 Impacts on Housing

It has been proposed that Newfoundland and Labrador Hydro supply and install two main construction camps with full living facilities. One is to be located in the Devil Cove area and the other in the vicinity of the Cat Arm Dam. Hydro will provide the nucleus of both construction camps to accommodate a total of 540 men prior to contractors mobilizing their own resources.

The facilities anticipated will form the initial camps and it is envisaged that these will be expanded by the contractor to meet his own particular operations and requirements. The basic camps will consist of water and sewage treatment plants capable of meeting the demands from a potential 700 man work force; accommodation in the form of bunkhouse units; kitchen/dining facilities for up to 700 men; and associated offices and warehouse facilities.

Reservoir clearing would probably require mobile camps which would be moved to suit the contractor's requirements.

Although Hydro will be providing accommodation for construction workers, it is anticipated that some workers will temporarily relocate their families to the development area. As noted, the closest communities (Jackson's Arm and Sop's Arm) are experiencing a housing shortage. Accommodation will also be required for sub-contractors who will be employed in the area. These will be one or two man operations who would normally find accommodation in a boarding house. The development will aggravate the existing housing shortage. It appears inevitable that accommodations, in addition to the construction camps will be necessary. Pre-fabricated homes or trailers will have to be brought into the communities of Jackson's Arm and Sop's Arm or the surrounding area, and water and waste disposal systems installed. The family housing units required are difficult to quantify because the number of families that would move into the area is unknown however, since other accommodation is not available in the area, it is estimated that 12 family housing units should be installed in close proximity to schools and other community services. In addition, consideration should be given to expanding construction camp facilities to accommodate subcontractors, as well as their need for vehicle storage space and fuel supplies.

4.6.5 Impacts on Community Services

The labour force associated with the development is small compared to the population of the study area however, most of the population of the area is concentrated in Deer Lake which, a distance of 114 km from Jackson's Arm. The major impact on community services would be in Jackson's Arm and Sop's Arm. The impact on these communities' social services is expected to be substantial because of developments in the fishery discussed earlier. The Cat Arm Development is expected to put further strain on social, health, law enforcement, educational and recreational facilities.

After the construction of the development has ended, the requirements for services will remain much the same because of the anticipated increase in population resulting from the fishery expansion. The Cat Arm Hydro Development will aid residents in obtaining these services at an earlier date.

A. Emergency Health Services

Medical services in the study area, excluding Deer Lake, are limited to a dentist in Sop's Arm, a nurse in Jackson's Arm and one doctor, located in Hampden, who visits Jackson's Arm and Sop's Arm one day a week. Deer Lake has a full-time nurse, three doctors and x-ray and laboratory facilities with technicians. An ambulance service exists between Deer Lake and Western Memorial Hospital in Corner Brook, a distance of 50 km.

The Cat Arm Development and the expansion of the fishery will cause an increase in the number of people using the available health services in Jackson's Arm and will result in further straining this service. A full-time doctor, an additional nurse and an ambulance service may be required.

B. Law Enforcement

An immediate increase in the volume of traffic is anticipated because of an increase in the number of tractor trailors transporting fish from the expanded fish plants in the area. Additional traffic will be generated by the development. This increase in traffic, (combined with the expected increase in population as discussed earlier), will exert pressure on the services presently provided by the Deer Lake detachment of the RCMP. An additional one or two RCMP officers may be required in the area during the construction of the development.

C. Educational Facilities

The closest communities of Jackson's Arm and Sop's Arm will receive the greatest impact on educational facilities. Jackson's Arm presently has 151 students enrolled in grades kindergarten to eight. Sop's Arm has three schools: a primary (Kindergarten to grade 3) with 40 - 50 students enrolled; an elementrary (Kindergarten to Grade 5) with 128 students enrolled; and a high school (grades 6 - 11) with 147 enrolled. Grade 9 - 11 students from Jackson's Arm travel by bus to the Sop's Arm High School. This will be extended to include 19 grade 8 students in September and possibly grade 7 students in 1981. The school at Jackson's Arm has reached its capacity. The Deer Lake Integrated School Board is in the process of acquiring a suitable site for a new school in Jackson's Arm however, there are no definite plans for new school construction in the area. The high school at Sop's Arm is capable of accommodating an additional 50 students.

During the construction stages of the development there are expected to be some new families temporarily residing in the Jackson's Arm/Sop's Arm area. The number of school age children included in these families is not known but these children, in addition to any resulting from the anticipated population increase in the area, will probably over- tax the present school facilities. An additional one or two teachers and classroom space will be required.

D. Recreational Facilities

The only recreational facilities in the study area are operated by volunteer organizations. The recreation committees of Jackson's Arm and Sop's Arm each have a building which is used for recreational activities such as dancing.

During the development, the need for other recreational facilities will certainly increase especially at the construction camp. A recreation building at the construction camp and a playground in Jackson's Arm may warrant consideration.

5. PUBLIC PARTICIPATION

Recognizing the importance of soliciting public opinion and allowing for public participation in the environmental assessment of the proposed Cat Arm Development, a public opinion survey and information meetings were conducted at various stages of the assessment. A detailed description of the public opinion survey is available in the socio-economic impact assessment report (Saga, 1980). The following sections summarize the results of the public opinion survey and report the questions and concerns raised during the public meeting held in Jackson's Arm on October 16, 1980.

5.1 Public Opinion Survey

During March, 1980 a public opinion survey was conducted in the communities most likely to be directly affected by the proposed Development. Approximately 50 percent of the survey sample resided in the Jackson's Arm-Sop's Arm area, with the remainder residing in either Hampden, Deer Lake, Howley, Cormack, Reidville or Nicholsville.

The intent of the survey was to gain an appreciation of the attitudes and concerns of local residents relating to the proposed Development in order to better assess probable and possible impacts on the local communities. A questionnaire, administered randomly by telephone, was designed which attempted to measure the following variables:

- awareness of the proposed Development;
- positive and negative attitudes towards the proposed Development;
- expectations of the Development for their community and themselves;
- concern over possible ecological or asthetic impacts;
- amenability to new people in their community;
- concern of new business coming into the community; and,
- various demographic and socio-economic information including age, sex, family size, occupation and income.

Tables 37 to 44 summarize the findings of the survey. In general, in-close respondents (those residing in Jackson's Arm/Sop's Arm) mentioned a number of changes they would like to see implemented in their community, with the most commonly mentioned expectation that of upgraded roads. Given the fact that these responses were generally unaided, this further signifies the importance respondents attach to improvements in this area.

In-close respondents were particularly confident about their future and felt the prospects for their community to be excellent. Most of those who felt this way about their community attributed it to the fish plants. The fish plants in the area are currently expanding premises, and for many in-close respondents appear to offer superior present and future returns.

There was a definite tendency for in-close respondents to agree with many of the requirements related to the progression of their community. Over 90% agreed that a community must grow in order to survive and that new money coming into a community benefits residents. However, strongly held beliefs, based on the long time isolation of these communities, were still evident. Many in-close respondents agreed that outsiders reduce community cohesion. Yet, in-close respondents favor many changes (e.g. population, modernization) for their community. Considering this altogether, in-close respondents seem willing to forego part of their traditional ways for a newer, more modern way of life but this position should be qualified. These respondents were willing to trade-off the old for the new, to a point. They still want to maintain 'control' over their way of life. This is evident by the large number of in-close respondents (65%) who felt there should be limitations put on businesses moving into the area.

Awareness levels of the proposed Cat Arm Development were not high. Only 11.5% of all respondents mentioned Cat Arm on an unaided basis, while 26% mentioned the project on an aided basis. In total, when asked directly, 57.5% of the sample were to some extent aware of the proposed project.

Respondents from all eight communities included in the study area, aware of the proposed Cat Arm Development, most often mentioned increase employment and cheaper electricity when questioned on the benefits such a project would bring to their community. Few respondents interviewed associated any negative effects with the proposed Cat Arm Development.

5.2 Public Information Meeting

A public information meeting was held in the Jackson's Arm Community Recreation Centre on October 16, 1980. Notices advertizing the meeting were posted in the communities of Jackson's Arm, Sop's Arm and Hampden, and placed in the regional newspaper, "Humber Log". The intent of the meeting was to provide information on the proposed project to interested members of the public and to allow for expression of questions and concerns to be raised and addressed by Hydro representatives.

Approximately 80 individuals attended the meeting. The majority of those in attendance resided in the local communities of Jackson's Arm and Sop's Arm. In addition five representatives of government agencies (Department of Municipal Affairs and Department of Environment) were present from St. John's and Corner Brook headquarters.

A presentation of the proposed Development was given by Hydro representatives and included a discussion of need, alternatives, construction design and schedule, and the findings of the environmental assessment studies. Visual aides such as slides and maps were used to assist in the presentation.

A question and answer period then followed. The questions raised by those in attendance included:

Q.1. (local resident) If it takes four years to build Cat Arm and power is needed by fall of 1984 it seems that a decision to build Cat Arm is needed in 1980. Since it appears that there will not be a quick decision on a Labrador In-feed, will the decision to build Cat Arm be made before the Labrador In-feed decision?

Q.2. (government official) How many jobs will be associated with peak construction and the operation of Cat Arm?

Q.3. (local resident) Outline the impacts on the local communities during the construction of Cat Arm.

Q.4. (government official) How large will the catering staff be at the construction camps and how many of these positions will be available to women?

Q.5. (local resident) What is the schedule of construction start-up and when will the road work be conducted?

Q.6. (government official) Will roads be open or closed during operation?

Q.7. (government official) Will the number of fish increase in the future reservoir?

Following the question and answer period refreshments were provided by the Jackson's Arm Anglican Women's Association which allowed for a less formal and more individual discussion of the proposed Development.

In general the concerns expressed during the public information meeting concurred with those identified by the public opinion survey. Employment opportunities and the potential impacts on the local communities were the major concerns expressed. Most individuals seemed to be willing to accept those environmental impacts identified as being associated with the proposed Cat Arm Development. Strong objections to the Development were not raised during the public meeting nor expressed during the public opinion survey.

Table 37

ARE THERE ANY CHANGES YOU WOULD LIKE TO SEE IN YOUR COMMUNITY?
(DON'T READ LIST, CHECK MORE THAN ONE IF APPROPRIATE)

	Mentioned n	Percentage %	Did Not Mention n	Not Asked n	Total n
Roads Upgraded	103	67.7	49	179	331
Telephone Service	8	5.3	144	179	331
More Planned Development	2	1.3	150	179	331
Increased Employment	6	3.9	146	179	331
Second Television Station	15	9.9	137	179	331
Improved Water System	18	11.8	134	179	331
Working Community Council	11	7.2	141	179	331
Faster Development	2	1.3	150	179	331
More Commercial Outlets	4	2.6	148	179	331
Better Recreational Facilities	31	20.4	121	179	331
Improved Medical Service	15	9.9	137	179	331
More Fishermen Rights	6	3.9	146	179	331
None	23	15.1	129	179	331
Other	49	32.2	103	179	331

SOURCE: Saga (1980)

Table 38

WHAT TYPE OF FUTURE DO YOU FORESEE FOR YOUR COMMUNITY?
(DON'T READ LIST, CHECK MORE THAN ONE IF APPROPRIATE)

	Mentioned n	Percentage %	Did Not Mention n	Not Asked n	Total n
Good	115	75.6	37	179	331
Stagnant	11	7.2	141	179	331
Poor	18	11.8	134	179	331
Minerals	7	4.6	145	179	331
Bowaters	6	3.9	146	179	331
Fish Plants	80	52.6	72	179	331
Cat Arm	18	11.8	134	179	331
Forestry	4	2.6	148	179	331
Electricity	6	3.9	146	179	331
Increased Facilities	4	2.6	148	179	331
Tourism	1	0.7	151	179	331
Reduced Salmon Licensing	3	2.0	149	179	331
No Employment	5	3.3	147	179	331
Other	20	13.2	132	179	331

SOURCE: Saga (1980)

Table 39

PLEASE TELL ME WHETHER YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS AS I READ THEM

	Agree n	Percentage %	Disagree n	Missing n	Not Asked n	Total n
A community must grow in order to survive	144	94.7	8	-	179	331
Recreational facilities are very important to a community	149	98.0	3	-	179	331
New money coming into a community benefits its residents	148	97.4	4	-	179	331
Outsiders tend to reduce community cohesion/ closeness	82	54.0	69	1	179	331
Large construction projects always destroy the natural habitats of wildlife	93	61.2	53	6	179	331
New roads into the wilderness are an advantage of any construction in an area	120	78.9	29	3	179	331
Benefits of large construction projects are only short term	94	61.8	55	3	179	331
An influx of construction workers is a nuisance to a community	68	44.7	78	6	179	331

SOURCE: Saga (1980)

Table 40

NOW ~~COULD YOU~~ TELL ME WHETHER YOU FAVOR OR DO NOT FAVOR EACH OF THE FOLLOWING CHANGES FOR YOUR COMMUNITY

	Favor n	Percentage %	Not Favor n	Missing n	Not Asked n	Total n
An increase in population	127	83.5	23	2	179	331
An increase in outsiders moving into your community	121	79.6	29	2	179	331
Modernization of the community	135	88.8	14	3	179	331
A work camp nearby the community	112	73.7	34	6	179	331
More housing and construction in the area	140	92.1	9	3	179	331
Limitations on businesses moving into the area	98	64.5	52	2	179	331
Increased access to other areas of the Province	139	91.4	10	3	179	331
Increased accesses to nearby wilderness areas	105	69.1	44	3	179	331

SOURCE: Saga (1980)

Table 41

ARE YOU AWARE OF ANY PROPOSED MAJOR CONSTRUCTION IN THIS AREA? (UNAIDED)

	Yes n	Percentage %	No n	Missing n	Not Asked n	Total n
Are you aware of any proposed major construction in this area? (Unaided)	138	41.7	187	6	-	331

IF YES, WHICH ONE(S)?

	Mentioned n	Percentage %	Did Not Mention n	Missing n	Not Asked n	Total n
Fish Plants (Unaided)	54	16.3	271	6	-	331
Hinds Lake (Unaided)	12	3.6	313	6	-	331
Cat Arm (Unaided)	38	11.5	287	6	-	331
Other (Unaided)	73	22.1	252	6	-	331

SOURCE: Saga (1980)

Table 42

ARE YOU AWARE OF A HYDROELECTRIC PROJECT IN THIS AREA? (AIDED)

	Yes n	Percentage %	No n	Missing n	Not Asked n	Total n
Are your aware of a hydro-electric project in this area (Aided)	178	53.8	146	7	-	331

IF YES, WHAT IS ITS NAME(S)?

	Mentioned n	Percentage %	Did Not Mention n	Missing n	Not Asked n	Total n
Hinds Lake (Aided)	69	20.8	249	13	-	331
Cat Arm (Aided)	87	26.3	231	13	-	331
Both HInds Lake and Cat Arm (Aided)	6	1.8	312	13	-	331

ARE YOU AWARE OF A HYDROELECTRIC PROJECT IN CAT ARM?

	Yes n	Percentage %	No n	Missing n	Not Asked n	Total n
Are you aware of a hydro-electric project in Cat Arm?	191	57.7	137	3	-	331

SOURCE: Saga (1980)

Table 43

WHAT DO YOU FEEL WILL BE THE BENEFITS, IF ANY, OF THIS PROJECT TO YOUR COMMUNITY?

	Mentioned n	Percentage %	Did Not Mention n	Not Asked n	Total n
Upgraded Roads	21	11.0	170	140	331
Better Medical Services	2	1.0	189	140	331
Improved Educational Facilities	1	0.5	190	140	331
Cheaper Electricity	86	45.0	105	140	331
Increased Employment	109	57.1	82	140	331
Influx of New People	11	5.8	180	140	331
Short Term	7	3.7	184	140	331
Indirect	4	2.1	187	140	331
Very Little	9	4.7	182	140	331
Don't Know	30	15.7	161	140	331
Other	24	12.6	167	140	331

SOURCE: Saga (1980)

Table 44

WHAT DO YOU FEEL WILL BE THE NEGATIVE ASPECTS, IF ANY, OF THIS PROJECT WITH RESPECT TO YOUR COMMUNITY?

(DO NOT READ LIST, CHECK MORE THAN ONE IF APPROPRIATE)

	Mentioned n	Percentage %	Did Not Mention n	Not Asked n	Total n
Type of people that could move in	4	2.1	187	140	331
Environmental Change	10	5.2	181	140	331
Lay off men in Powerhouse	2	1.0	189	140	331
Temporary Boom and Money	2	1.0	189	140	331
Don't Know	72	37.7	119	140	331
Very Little	10	5.2	181	140	331
None	83	43.5	108	140	331
Other	7	3.7	184	140	331

SOURCE: Saga (1980)

6. MITIGATING MEASURES

Throughout the Cat Arm environmental assessment, impacts have been identified which will likely occur as a result of the proposed Development. These impacts have been summarized generally in earlier sections of this EIS and are reported in more specific detail in each of the associated consultant reports. This section gives a list of specific actions which will mitigate against potential impacts of the proposed Development. These measures are based on the results of the environmental studies as well as an open exchange of ideas between government regulatory agencies, public interest groups and members of Hydro's technical staff.

Many of the following mitigating measures have already been implemented. This is especially true for those mitigations which affect the Development design. Other mitigations will not be implemented until the actual construction phase and are closely tied to the environmental monitoring program. The majority of mitigations fall into this catagory and rely on technical and/or timing solutions.

In addition to those impacts for which mitigation has been identified, a number of impacts exist which, due to the nature of the proposed Development, are non-mitigatable. These include such impacts as the loss of wildlife habitat due to creation of the reservoir and construction of major civil works, the diversion of natural water courses and subsequent change in local water quality and fish habitat, and increased access to a region of the province which until now has been a relatively isolated and unprotected wilderness area.

Underlying the commitment to complete the following mitigating measures is an appreciation of the need for the proposed Cat Arm Hydroelectric Development to be constructed in a manner which will protect present and future wilderness value of the area. To accomplish this, many of the mitigating measures listed below have been designed to minimize visual intrusion and thereby retain the scenic value of the area. These include the permanent access road and transmission routing, borrow material and disposal sites, reservoir clearing, and downstream channel improvements on the Cat Arm River.

It is the intent that the following mitigating measures will ensure, in a practical, economic and scientifically sound manner, that potentially adverse impacts will be minimized if not eliminated altogether, and that potential benefits will be maximized.

6.1 Access Roads and Transmission Corridor

- Temporary roads will be located within the future flood zone wherever possible.
- Temporary road surfaces will be kept narrow with natural vegetation maintained close to its edge. Stripping of the road right-of-way will be kept to a minimum.

- Roads will avoid important wildlife habitat wherever possible.
- Restriction of existing drainage patterns will be minimized by the installation of culverts in appropriate locations.
- Stream crossings will be located where disruption of streambeds and flow is minimal and in such a manner as to protect existing fish habitat, migration and populations. Fording will be kept to a minimum.
- Any archaeological artifacts uncovered during construction will be reported to the on-site environmental monitor and the Provincial Historic Resources Division. Construction activity will be halted until the area of the find has been examined by a professional archaeologist.
- Use of roads during the construction phase will be restricted to only those individuals associated with the Development and will be controlled by the installation of a permanent inspection gate.
- Temporary roads not used after the construction period will be left in such a state that will prevent future access and will allow speedy regeneration of natural vegetation.
- The location of the transmission line and new permanent access road will be within the same corridor, with the distance between the two less than 1 km.

- The transmission corridor will not exceed 38 m in width. Outside the right-of-way, hazard trees only will be removed.

6.2 Construction Camps

- Sewage and waste water will be treated before disposal.
- Garbage will be disposed in a manner which will not attract wildlife.
- Safety regulations designed to prevent spills of fuel and hazardous chemicals will be strictly enforced.
- Hunting, fishing and/or trapping by members of construction crews, while resident at construction camps, will be done in accordance with existing Provincial and Federal statutes and regulations.
- Disassembly of the construction camp will be done in a manner which will allow the camp area to recover the natural conditions in a minimal time period.
- Workers will not be allowed firearms in the camp or in the Development area.

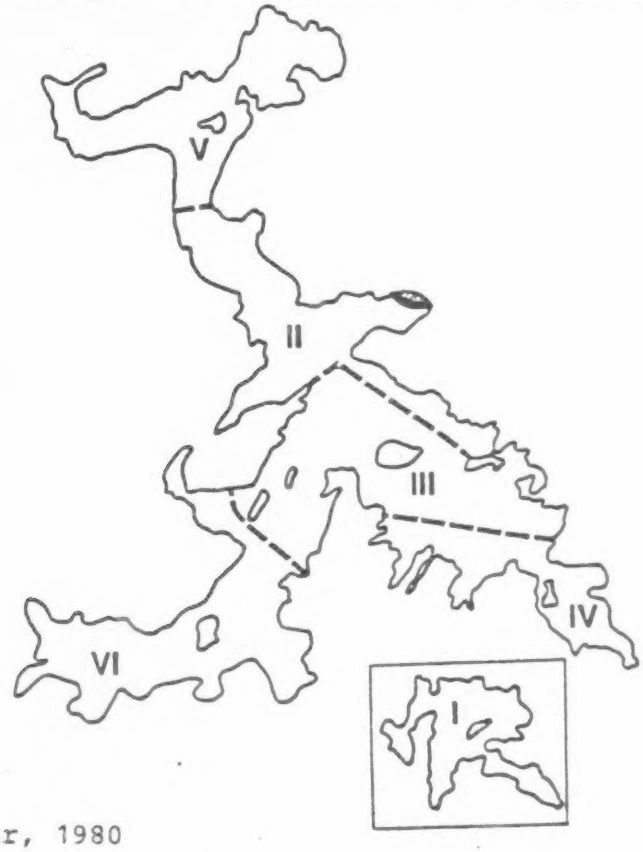
6.3 Reservoir Preparation

- A reservoir clearing strategy will be implemented to reduce negative ecological effects and to improve shoreline succession, aesthetics and recreational opportunities of the reservoir.

- Vegetation within the area between two vertical meters below low supply level and one vertical meter above full supply level in Areas II, III, and V of the main reservoir will be clear-cut and burned (see Figure 30). Vegetation in Area I (Forebay) shall be totally cleared and burned.

Figure 30

Clearing Blocks For Cat Arm Reservoir Preparation



SOURCE: Hunter, 1980

- Merchantable timber throughout the reservoir area will be harvested where economically feasible.

- Safety regulations will be strictly enforced to control fires, wildlife harassment and the cutting of forest beyond the specified clearing limits.

- Refuelling, storage of toxic materials and garbage disposal will take place outside of the reservoir zone wherever possible, and not contaminate streams or groundwater.

- Methods of timber and scrub cutting and disposal will be in accordance with the Department of Forestry and Agriculture requirements.

6.4 Borrow Material, Quarry and Excavation Sites

- Borrow material and quarry sites will be located as close as possible to the sites where the material is being used, with maximum use of those sites located along the permanent access routes and within the future reservoir [illegible]

- Borrow and disposal sites will be approved in accordance with Provincial Statutes and Regulations.

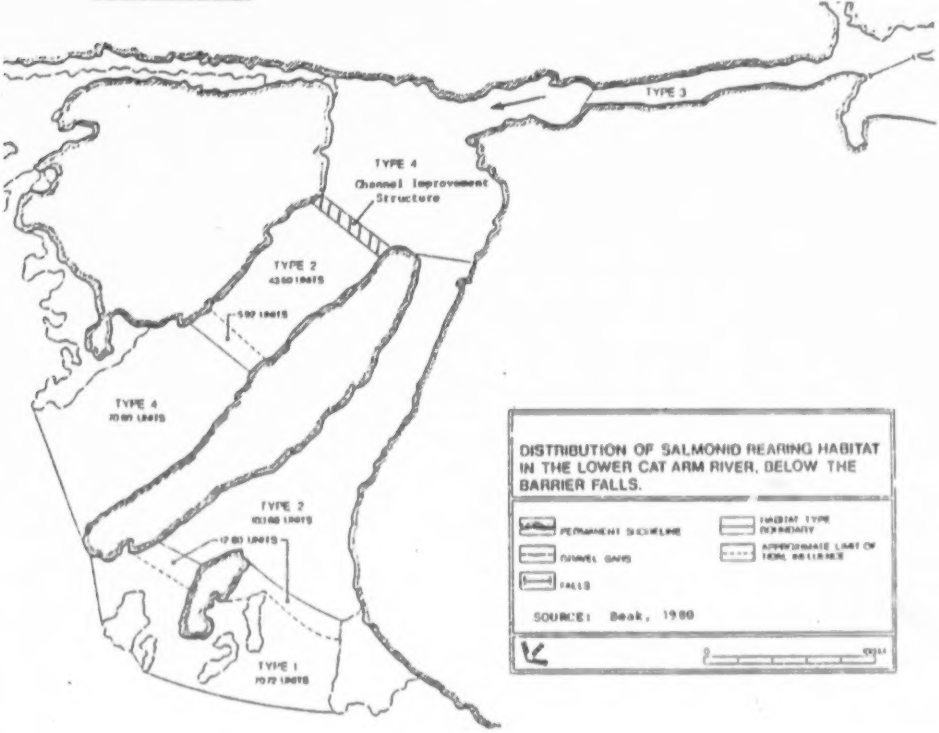
- Excavated material will be used as much as possible during construction of civil works.

- Environmentally sound construction practices will be enforced by the on-site monitor to control erosion and sedimentation into any adjacent waterbodies and/or streams.

6.5 Downstream Channel Improvements

- Channel improvements will be installed at the mouth of the Cat Arm River. Natural recovery water flows will be controled and diverted in a manner which will protect existing salmonid habitat (see Figure 31).

Figure 31


TYPE 3
TYPE 4
Channel Improvement Structure
TYPE 2
TYPE 4
TYPE 2
TYPE 1
PERMANENT SHORELINE
GRAVEL BARS
FALLS
HABITAT TYPE BOUNDARY
APPROXIMATE LIMIT OF TIDAL INFLUENCE

DISTRIBUTION OF SALMONID REARING HABITAT IN THE LOWER CAT ARM RIVER, BELOW THE BARRIER FALLS.

SOURCE: Beak, 1980

- Environmentally sound construction practices will be enforced by the on-site monitor to control disruption and sedimentation of existing habitat.

6.6 Monitoring Program

A comprehensive environmental monitoring program will be developed and implemented by Hydro. This program will include on-site monitoring of all activities during the construction phase as well as a long-term post-construction inspection of the Development.

Major components of this program will include:

- the presence of a full-time Hydro environmental monitor on-site during the construction phase,
- inclusion of environmental clauses in all contracts associated with the Development (see Appendix III,
- strict enforcement of all specifications as outlined in approvals and permits by regulating agencies,
- ensuring the successful implementation of mitigating measures,
- water quality measurement in the future reservoir, the Great Cat Arm, and Devil Cove,
- inspection of vegetation regeneration areas, roads, stream crossings, and other areas of the Development,
- maintenance of channel improvement facilities in Cat Arm River, and,
- addressing any unforeseen problems which may develop that inpinge on the quality of the environment in the Cat Arm area.

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APPENDIX I

AVIFAUNA SPECIES EXPECTED TO OCCUR IN CAT ARM AREA

APPENDIX I

A List of Avifauna Species Expected to Occur in Cat Arm Area

Species	Relative Abundance and Seasonality
Anseriformes (Ducks)Geese, and Gaviforms (Loons)	
Common Merganser	-uncommon, year-round resident
Canada Goose	-fairly common, summer resident (a few remain in winter)
Common Goldeneye	-fairly common, year round resident
Bufflehead	-uncommon, winter resident only
Ring-necked Duck	-rare, summer resident
Harlequin Duck	-rare, year-round resident
Black Duck	-most abundant of the ducks in Newfoundland, mainly summer resident
Green-winged Teal	-common, summer resident
American Common Eider	-winter visitor only (?), formerly bred in inland part of province
Common Loon	-common, summer and occasional winter resident
Ciconiiformes (Herons and Allies) and Charadriiformes (Shorebirds)	
American Bittern	-uncommon, summer resident
Common Snipe	-common, summer resident
Greater Yellowlegs	-abundant, summer resident
Least Sandpiper	-uncommon, summer resident
Spotted Sandpiper	-abundant, permanent resident
Ring-billed Gull	-uncommon, summer resident
Common Tern	-common, summer resident

Species	Relative Abundance and Seasonality
Caspian Tern	-rare, summer resident
Galliformes (Upland Game Birds)	
Rock Ptarmigan	-common, permanent resident
Willow Ptarmigan	-common, permanent resident
Ruffed Grouse	-rare, permanent resident
Coraciiformes, Piciformes and Passeriformes (Kingfisher, Woodpeckers and Passerine Species)	
Belted Kingfisher	-fairly common, summer resident - occasionally winter resident
Common Flicker	-common, summer resident - rare in winter
Yellow-bellied Sapsucker	-uncommon or rare
Hairy Woodpecker	-fairly common, permanent resident
Downy Woodpecker	-fairly common in interior of province, permanent resident
Black-backed Three-toed Woodpecker	-uncommon, permanent resident
Northern Three-toed Woodpecker	-rare, permanent resident
Yellow-bellied Flycatcher	-abundant, summer resident
Traill's Flycatcher	-uncommon, summer resident
Olive-sided Flycatcher	-uncommon, summer resident
Horned Lark	-common summer resident, uncommon winter resident
Tree Swallow	-common, summer resident
Gray (Canada) Jay	-common, permanent resident
Blue Jay	-fairly common locally (including Humber River and Valleys) permanent resident
Common Raven	-common, permanent resident
Black-capped Chickadee	-common, permanent resident

Species	Relative Abundance and Seasonality
Boreal Chickadee	-abundant, permanent resident
Red-breasted Nuthatch	-uncommon in summer, rare in winter
Winter Wren	-uncommon in summer, rare in winter
American Robin	-abundant in summer, uncommon in winter
Hermit Thrush	-common, summer resident
Swainson's Thrush	-common, summer resident
Gray-cheeked Thrush	-common locally on Northern Peninsula, summer resident
Golden-crowned Kinglet	-common in summer, uncommon in winter
Ruby-crowned Kinglet	-common, summer resident
Water Pipit	-common, summer resident
Cedar Waxwing	-rare, summer resident
Common Starling	-rare to uncommon, permanent resident
Black-and-white Warbler	-fairly common, summer resident
Tennessee Warbler	-rare, western half of province only, summer resident
Yellow Warbler	-abundant, summer resident
Myrtle Warbler	-uncommon, summer resident
Black-throated Green Warbler	-fairly common as summer resident, except probably not present on Northern Peninsula until autumn
Blackpoll Warbler	-abundant, summer resident
Palm Warbler	-fairly common in interior, summer resident
Ovenbird	-status uncertain, probably summer resident in southern half of province
Northern Waterthrush	-common, summer resident
Wilson's Warbler	-abundant, summer resident
American Redstart	-abundant, summer resident

Species	Relative Abundance and Seasonality
Rusty Blackbird	-common, summer resident
Purple Finch	-common in interior, summer resident
Pine Grosbeak	-common summer resident, fairly common winter resident
Common Redpoll	-fairly common, permanent resident
Pine Siskin	-uncommon, summer resident (flocks seen in Codroy Valley and Long Range)
Red Crossbill	-fairly common in summer, uncommon in winter
White-winged Crossbill	-common locally, permanent resident
Savannah Sparrow	-abundant, summer resident
Slate-Colored Junco	-common in summer, uncommon in winter
White-crowned Sparrow	-uncommon summer resident, occurs in Northern Peninsula only
White-throated Sparrow	-abundant, summer resident
Fox-Sparrow	-abundant, summer resident
Lincoln's Sparrow	-fairly common, summer resident
Swamp Sparrow	-common, summer resident
Falconiformes	
Goshawk	-rare, uncertain - either summer or permanent resident
Sharp-shinned Hawk	-rare, permanent resident
Bald Eagle	-uncommon, summer resident
Osprey	-common, summer resident
Peregrine Falcon	-rare, may breed in province, but probably just migrates through in spring and fall

Species	Relative Abundance and Seasonality
Merlin	-common, summer resident
Strigiformes (Owls)	
Hawk Owl	-uncommon, permanent resident
Great Horned Owl	-fairly common, permanent resident
Short-eared Owl	-uncommon, summer resident
Snowy Owl	-uncommon, winter resident

SOURCE: Airphoto/Beak, 1976

APPENDIX II

GLOSSARY

GLOSSARY

Agglomerate:
a mass of rounded or sub-angular fragments of volcanic materials that have been explosively or aerially ejected from a volcanic vent.

Anadromous:
a term applied to certain fish, eg. a salmon, which spend most of their life in the sea and, after attaining sexual maturity, migrate up rivers to spawn.

Andesite:
a fine-grained green volcanic rock consisting of plagioclase feldspar, with dark ferromagnesian (mafic) minerals and little or no quartz.

Arkose:
a sandstone containing 25 percent or more feldspars, usually derived from the disintegration of acid igneous rocks of granitoid texture.

Batholith:
an igneous intrusive body of unknown depth with a surface exposure of more than 104 square kilometres. The sides of a batholith are usually steep and broaden with depth.

Benthic Production:
the rate of storage of energy from food by organisms (plants or animals) living on or in the substrate of waterbodies (see also primary productivity; secondary productivity; benthos).

Benthos:
organisms which live on and/or in the substrate of waterbodies.

Biomass:
the living weight of the producers (organisms capable of manufacturing food from simple inorganic substances eg. green plants) and the consumers (organisms which eat other organisms or particulate organic matter) in an ecosystem.

Biophysical Study:
a study to differentiate and classify significant areas of the land surface on an ecological basis; these data serve as the ecological bases for land use planning, involving future management of lands for forestry, agriculture, recreation, wildlife, etc.

Biota:
animal and plant life.

Bog:

a peat covered area or peat filled depression with a high water table and a surface capet of mosses, chiefly Sphagnum. The water table lies at the surface in the spring and slightly below the moss carpet during the rest of the year, but there is little standing water except for ponds. The mosses often form raised hummocks separated by low wet, narrow spaces.

Carrying Capacity:

the upper level of abundance of a population, in a particular area and under the prevailing conditions, beyond which no major increase can occur and be sustained.

Clastic:

consisting of rock fragments that have been mechanically derived, transported and deposited.

Chemical Oxygen Demand:

the weight of oxygen taken up by the total amount of organic matter in a sample of water.

Demography:

the science dealing with the distribution density, vital statistics, etc. of populations.

Detritus:

the particulate organic matter derived from the decomposition of dead organisms.

Drumlin:

an elliptical hill or mound, normally composed of glacial till, with one end usually somewhat higher than the other.

Dystrophic:

a term applied to waterbodies which generally have high concentrations of humic acid.

Ecology:

the study of the relationships between organisms and their environment (also known as environmental biology).

Ecosystem:

an ecological system involving the functioning together of all of the populations occupying a given area (= a community) and their non-living environment.

Epilimnion:

see Thermocline.

Euphotic Zone:

the stratum in a waterbody which lies between the water's surface and the limit of effective light penetration (where the light intensity is about one per cent of that of full sunlight).

Fauna:

a collective term for all animal life.

Fen:

peatlands characterized usually by poorly and moderately deposed peat of variable thickness, and covered by a dominant component of sedges, although grasses and reeds may be associated. Often there is much shrub cover and sometimes a sparse layer of trees, usually larch. The water table is at the surface most of the time and some standing water may occur in the spring.

Firm Capacity:

the minimum power capability of an hydro plant under the most unfavourable tailwater and headwater conditions.

Food Chain:

the transfer of energy from food from the source in plants through a series of organisms, with repeated eating and being eaten.

Full Supply Level:

the design anticipated maximum operating level of a reservoir for an hydro-electric generating plant.

Granite:

a plutonic rock consisting of greater than 10 per cent quartz, and at least twice as much potassium feldspar as plagioclase fedlspar. Biotite and muscovite are common mafic constituents.

Granodiorite:

a plutonic rock consisting of quartz, calcic oligoclase or andesine and orthoclase with some mafic constituents.

Gigawatthour (gWh):

a gigawatthour; this represents one million kilowatthours, the basic unit of electrical energy, ie. one kilowatt of power supplied by an electrical circuit continuously for one hour.

Habitat:

the place where an organism (plant or animal) naturally occurs.

Instar:

an immature stage in the development of an insect and most other invertebrates.

Invertebrate:
an animal without a backbone.

Lacustrine:
relating to a lake.

Littoral Zone:
the shallow water region of a waterbody with effective light penetration to permit the growth of green plants on the bottom.

Live Storage:
the volume of water in a reservoir lying between full supply level and low supply level.

Low Supply Level:
the design anticipated lowest operating level of a reservoir for an hydro-electric generating plant; this level is expected only during the year(s) of lowest inflows on record, or lower.

Macrophyte:
a large aquatic plant.

Megawatt (MW):
one thousand kilowatts (see gigawatthour)

Moraine:
generally unsorted and structureless material, consisting of an homogeneous mixture of clay, silt, sand, gravel and large rock fragments, derived from the glacial erosion of bedrocks and deposited directly by glacial action.

Muskeg:
a kind of bog or marsh containing thick layers of decaying vegetable matter, mosses, etc.; often overgrown with moss.

Nanoplankton:
extremely small floating aquatic organisms.

Oligotrophic:
a term applied to waterbodies which are low in plant nutrients (oligo=few; trophos=food).

Ordovician:
a period in the history of the earth, occurring between 430 and 500 millions of years ago.

Periphyton:
small aquatic plants or animals attached or clinging to live or dead objects projecting above the bottom of a waterbody.

pH:
a measure of the degree of acidity or alkalinity of water and other fluids.

Physiography:
the description of the features and phenomena of nature (also called physical geography).

Phytoplankton:
small floating aquatic plants (= phyto), usually algae.

Plankton:
floating aquatic organisms whose movements are more or less dependent on currents.

Porphyry:
an igneous rock with large distinct crystals, especially of alkali feldspar, contained in a finegrained matrix.

Primary Energy:
energy available from firm power.

Primary Productivity:
(of an ecosystem or part of it) the rate at which the sun's radiant energy is stored by producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials (also called primary production).

Profundal Zone:
the bottom and deep areas of a waterbody which is beyond the depth of effective light penetration.

Put To Bed:
actions taken directed to helping accelerate returning a road location to its original natural condition by preventing usage by vehicular traffic. The actions include, but are not restricted to, removal of all culverts and the creation of barriers across the road, eg. trenches.

Rule Curve:
a guide to the annual variation in the volume of water in a reservoir and which is directed to ensuring the efficient operation of the hydroelectric plant.

Secondary Productivity:
(of an ecosystem or part of it) the rate of storage or energy from food by consumer organisms (also called secondary production).

Sedimentary:
a term applied to rocks which are composed of particles derived from previously existing rock, then laid down after transportation by streams, ocean or wave currents, wind or ice; the sedimentation also may result from chemical precipitation.

Shale:
a laminated sedimentary rock in which the constituent particles are predominantly silt or clay size.

Smolt:
a young salmon when it first leaves the river where it was spawned, migrating to a lake (land locked salmon) or, if accessible, to the sea.

Species:
the basic unit of classification in biology; a term applied to a group of organisms (plants or animals), all of which have a high degree of similarity, generally can interbreed only among themselves, and which show persistent differences from members of allied species (abbreviation: sp. (singular); spp. (plural)).

Standing Stock:
the number or weight of organisms in a location at any given time (also called standing crop).

Syenite:
a grey plutonic igneous rock containing principally alkalic feldspar usually with one or more mafic minerals such as hornblend or biotite.

Talus:
an accumulation of disintegrated rock material which has formed a slope at the base of a cliff or steeper slope.

Thermocline:
a horizontal zone in a waterbody in which there is a steep temperature gradient and which separates the waterbody into two layers which do not mix with each other, the uppe layer is called the epilimnion and the lower layer the hypolimnion.

Till:
non-sorted, non-stratified sediment carried or deposited by a glacier. Such a deposit may contain a mixture of fragments ranging in size from clay particles to boulders many metres in diameter.

Trophic Level:
the position an organism occupies in a food chain.

Tuff:
a fine-grained volcanic rock composed of fragments, generally smaller than 4mm in diameter.

Tripton:
the non-living particulate matter found in water.

Univoltine:
a term applied to insects which have one generation per year.

Zooplankton:
small floating aquatic animals.

METRIC ABBREVIATIONS AND EQUIVALENTS

Unit	Abbreviation	Equivalent
Length		
Micron	μm	0.0001 cm
Millimetre	mm	0.10 cm
Centimetre	cm	10 mm
Metre	m	100 cm
Kilometre	km	1,000 m
Area		
Square Metres	m^2	10,000 cm^2
Hectare	ha	10,000 m^2
Volume		
Millilitre	ml	1.0 cm^3
Litre	1	0.001 m^3
Cubic Metre	m^3	1,000,000 cm^3
Weight		
Kilogramme	kg	1,000 g

$10,000 = 1.0 \times 10^4$

$0.01\ m^2 = 1.0 \times 10^{-2}\ m^2$ $100\ m^2 = 1.0 \times 10^2\ m^2$

APPENDIX III

ENVIRONMENTAL PROTECTION CLAUSES FOR INCLUSION IN TENDER AND CONTRACT SPECIFICATIONS AND/OR INSTRUCTIONS TO MANAGERS

ENVIRONMENTAL PROTECTION

Owner's Policy

It is the Owner's policy to protect the environment of the areas where the project is located. To ensure the protection of the environment the Work at all times shall be subject to inspection by Owner, its Environmental Staff, and Staff of relevant Provincial and Federal agencies. Normally, all inspections other than by Owner will be arranged in advance through Owner. Any specific matters relating to environmental protection will be dealt with between the Contractor and Owner.

Contractor's Responsibilities

(i) Contractor shall ensure that its employees and its Sub-contractors and their employees comply with all applicable environmental rules, regulations and requirements of Federal, Provincial and Municipal authorities, and such other rules and regulations as Owner may establish. Some specific requirements are detailed in the following Sections.

(ii) Contractor shall be responsible for the obtaining of all necessary permits and approvals to comply with government laws and regulations.

Personnel

(i) All government rules and regulations pertaining to fish and wildlife (e.g. harassment), forest fires, forest travel, smoking and littering shall be complied with by all Contractors, Subcontractors and their employees. In addition there shall be no hunting, trapping or shooting on the Jobsite.

(ii) No firearms shall be permitted on the Jobsite, other than sealed units for predator control, under the supervision of Owner.

(iii) The operation of mobile ground equipment shall be restricted to the immediate Jobsite area or established roads, and Contractor shall not permit the use of its vehicles for recreational purposes on the Jobsite.

ENVIRONMENTAL PROTECTION (CON'T)

Personnel (Con't)

(iv) Tracked or all-terrain vehicles, other than required to perform the Work shall not be permitted on the Jobsite without specific consent of Owner.

(v) Any contravention of environmental regulations, including employee actions accidental or otherwise, resulting in environmental damage shall be reported to Owner without delay. Contractor shall be responsible for clean-up, reclamation and/or restorative measures as may be directed by Owner.

Prevention of Pollution of Watercourses

Contractor shall take all necessary measures to prevent the introduction either directly or indirectly of any polluting material into the watercourses feeding existing water supply systems, their watershed areas, and their overflows.

Polluting material will be defined as any material whether it be solid or liquid, bacteriological, organic, or inorganic, which would be harmful or obnoxious to the consumers of water from the supply.

All necessary measures shall be enforced for the whole of the period of construction, and shall prevent pollution caused by Contractor's labour force, equipment, and construction methods. Possible sources of pullution against which provision shall be made shall include, but not necessarily be limited to, sanitation facilities, vehicle servicing, material dumped without Owner's approval, and the passage of vehicles through watercourses.

In the event of contamination of a watercourse, Contractor shall take all necessary measures to neutralize any and all effects of the pollution and to restore the water quality and quantity in the affected water supply system to the condition in which it was prior to the contamination occurring. In addition, Contractor shall, where required by the relevant Water Authority, take all necessary measures to provide to the affected system a supplementary supply of water equal in quality and quantity to that which was in the supply system prior to the contamination occurring.

Fuels and Oils

(i) Registration of Storage Tank Systems

Any person operating or intending to operate a storage tank system is required to file a proposal or to register

ENVIRONMENTAL PROTECTION (CON't)

Fuels and Oils

(i) Registration of Storage Tank Systems (Con't)

the storage tank system. This regulation does not apply to above ground and underground storage tanks of a capacity less than 2300 litres connected to a heating appliance or to overhead tanks of a capacity less than 2300 litres.

(ii) Locations of Storage Tank Systems

Oils, greases, gasoline, diesel or other fuels shall be stored at least 150 metres from any surface waters unless otherwise approved by Owner.

(iii) Handling and Fueling Procedures

Handling and fueling procedures shall be such that contamination of ground and water shall not occur.

(iv) Dykes

Any fuel container with a capacity of 23,000 litres or more shall be positioned over an impervious mat and shall be surrounded by an impervious dyke of sufficient height (minimum height 0.6 metres) to contain not less than one hundred and ten percent (110%) of the capacity of the tank.

When more than one tank is enclosed in the dyke area, the dyke shall be of sufficient height to contain the volume of the largest tank plus the greater of ten percent (10%) of the aggregate volume of all the other tanks or ten percent (10%) of the volume of the largest tank.

All dykes of earthwork construction shall have a flat top not less than 0.6 metres wide.

The distance between a storage tank shell and the center line of a dyke shall be at least one-half (0.5)the tank height.

Any fuel container with a capacity between 4,500 litres and 23,000 litres shall be similarly dyked if it is to remain at a site for more than six (6) months. Fuel containers of less than 4,500 litres capacity do not require dyking.

ENVIRONMENTAL PROTECTION (CON'T)

Fuels and Oils (Con't)

(v) Waste Oil Disposal

Waste oils and lubricants shall be retained in closed containers and disposed of in a manner subject to Owner's approval.

(vi) Contractor's Responsibilities

Contractor shall institute a daily inspection of the storage tank system so that any 24-hour loss greater than normal (normal is defined as one percent of the capacity of the storage tank or one percent of the volume of the product conveyed through the storage tank system, whichever is greater) or any spill (spill is defined as any loss of product in excess of 68 litres can be detected immediately, dealt with and a clean-up carried out. The Contractor shall make a full report of any such incidents.

Before transporting or positioning fuel or oil for use in connection with the Work, Contractor shall present to Owner a contingency plan acceptable to Owner for dealing with fuel or oil spills.

(vii) Abandonment

The owner of the storage tank system shall, within thirty (30) days of known abandonment, empty the system of all products, remove the tank and associated piping from the ground, remove any contaminated soil, clean the area and restore the environment to the satisfaction of Owner.

Pesticides and Other Toxic Materials

No pesticides or other toxic chemicals shall be used without prior approval of Owner. Each chemical to be used, its application, restraint, and area of use shall be subject to regulation under the Newfoundland Pesticides Control Act.

Clearing and Construction

(i) General

Contractor shall ensure that tote roads, access roads or other disturbances to the terrain do not form barriers that cause flooding with possible resultant distruction of vegetation.

ENVIRONMENTAL PROTECTION (CON'T)

Clearing and Construction (Con't)

(i) General (Con't)

Borrow pits shall be located so as to maintain a minimum vegetation buffer zone, 150 metres in width, from any water body. Deviations from this requirement may be made at the discretion of Owner. A buffer zone having a minimum width of 30 metres shall be left between any borrow area and the right-of-way.

Overburden removed in the development of borrow pits shall be piled so as to be available for restoration purposes.

Borrow pits shall be developed and left in a condition such that any erosion is contained within the pit.

Destruction, removal or clearing of trees shall not be done to any greater extent than necessary for the performance of the Work.

Slash shall be piled at the edges of the right-of-way so as not to cause unnecessary disfigurement of vegetation outside of the right-of-way.

(ii) Fish Habitat Protection

It should be recognized that streams containing gravels of 7 5 millimetres or less in diameter, and with moderate water velocities, are capable of providing spawning areas for trout. With respect to salmon, the gravel size may be as large as 150 millimetres.

(iii) Buffer Zone

To avoid disturbances of ground vegetation so as to prevent erosion, road locations and overland vehicle movement shall not be permitted within 100 metres of any water body (such area being designated a buffer zone), other than for the tote road or stream crossings, or at Owner's discretion.

Cutting and skidding in a buffer zone shall proceed such that the ground vegetation is disturbed as little as possible. Skidding trails shall be perpendicular to the slope and lead to the central tote road.

ENVIRONMENTAL PROTECTION (CON'T)

Clearing and Construction (Con't)

(iii) Buffer Zone (Con't)

Slash and any other construction material or debris shall not be permitted to enter any water body, and shall be piled such that seasonal floodwaters cannot reach them.

(iv) Road Construction

Where a cut and fill slope is constructed within a buffer zone (as that term is used in the provisions of clearing (i) or (iii) hereof) it shall be stablized by either re-vegetation or the use of coarse rock. In all other areas stabilization is not required; however, slopes in the order of 1:2 are recommended.

(v) Stream Crossings

Existing crossings should be used wherever possible. Although the preference for crosssings is bridging, culverting and fording are acceptable crossing methods, particularly for small streams not possessing spawning potential at or below the stream crossing site. In any event, care shall be taken to ensure that a crossing does not become an obstruction to fish migration. Care shall be taken to ensure a minimum of erosion and situation as crossing approaches.

(vi) Fording

When crossing streams with heavy equipment the same place shall be used each time.

Fording activities shall not decrease the depth of a stream to less than 200 millimetres; where the existing depth is less than 200 millimetres; that depth shall be maintained.

Skidding across streams should be avoided. However, if this type of operation can be justified to Owner as necessary, the same crossing site shall be used at all times. In no event shall stream beds be used as skid roads.

The use of heavy equipment in stream beds shall be minimized.

Construction equipment shall not be parked in any water body.

Clearing and Construction (Con't)

(iv) Fording (Con't)

Gravel shall not be removed from a stream bed or bank, nor from the shoreline of a lake or pond.

Under Owner's specific direction, crossings shall be returned to as natural a condition as possible when no longer in use. Subject to Contractor having compiled fully with all applicable Governmental regulations (Federal, Provincial or Municipal) and the Owner's Environmental Policy as set out in this clause, restoration shall be at Owner's expense, but otherwise at Contractor's expense.

(viii) Culverts

Culverts shall be designed and installed such that they do not become obstructions to fish migrations and do not wash out.

Culverts shall be installed on a uniform slope, following the existing stream gradient, and set 150-300 millimetres into the stream bed.

Maximum slope of culverts shall comply with the following: culverts 15 metres or less, 5%; culverts 15-30 metres, 3%, and culverts 30 metres or greater, 1.5%.

Water velocity shall not be greater than 1.2 metres/sec in culverts under 25 metres in length, and not greater than 1 metre/sec in culverts over 25 metres in length.

Where directed by Owner fill approaches to culverts shall be stabilized by rip rap or abutment wings, at Owner's expense, other than where specifically identified in the contract, to prevent erosion of the road slope and consequent siltations of the stream.

Streams shall not be channelized without Contractor obtaining prior approval of the Fisheries and Marine Service.

Where two or more culverts are being placed in a stream, one shall be placed at a lower elevation than the other(s) to ensure that water is concentrated in that one culvert during periods of low flow.

Any clogged culverts shall be cleaned immediately when noted.

ENVIRONMENTAL PROTECTION (CON'T)

Clearing and Construction (Con't)

(ix) Ditches

Where roadside ditches lead directly to streams, they shall be provided with several baffles in the vicinity of the streams, to create areas where any silt will tend to settle out.

Other drainage ditches shall not lead directly to any body of water, and vegetation cover shall be maintained to permit settling of silt prior to its reaching any body of water.

(x) Marshalling Yards

Equipment and material storage yards shall be located at least 150 metres from any water body unless otherwise approved by Owner.

Protection of Archaeological and Historical Findings

All fossils, articles of value of antiquity, and other remains or things of geological or archaeological interest or value discovered on the site shall be deemed to be the absolute property of the Crown. Contractor shall take all reasonable precautions to prevent his employees or other persons from removing or damaging any such articles or thing, and immediately upon discovery thereof and before removal shall advise Owner of such discovery.

In event of such a discovery Owner's Environmental Policy is that the Work shall cease in the immediate area of the discovery until such time as Owner, having consulted the proper authorities, advises the Contractor as the disposition of the discovery and authorizes a renewal of the Work.

Volumetric measures as given in metric dimensions shall apply. Where existing containers of imperial measures are used, they shall be deemed to comply with the closest metric conversion within a tolerance of ± 1.5% of the given metric dimension.

APPENDIX IV

ASSESSMENT COMMITTEE
HYDROELECTRIC PROJECTS

APPENDIX IV

ASSESSMENT COMMITTEE
HYDROELECTRIC PROJECTS

CHAIRMAN:

Dr. D.H. Barnes
Environmental Biologist
Environmental Management & Control Div.
Dept. Consumer Affairs & Environment
Elizabeth Towers, 100 Elizabeth Avenue
St. John's, Newfoundland
A1B 1R9
TEL: 737-2562

MEMBERS:

Mr. H. Bain
Inland Fisheries & Habitat Mgmt.
Fisheries & Marine Service
Canada Dept. of Fisheries & Oceans
Northwest Atlantic Fisheries Center
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1
TEL: 737-4517

Dr. G.F. Bennett
Professor
Department of Biology
Memorial University of Nfld.
St. John's, Newfoundland
A1C 5S7
TEL: 753-1200 EXT. 2141

Mr. A.B. Case
Mechanized Operations Officer
Canadian Forestry Service
Nfld. Forest Research Centre
Building 304, Pleasantville
P.O. Box 6028
St. John's, Newfoundland
A1C 5X8
TEL: 737-4820

Mr. S. Clinton
Chief Regional Planner (East)
Urban and Rural Planning Div.
Dept. Municipal Affairs & Housing
Confederation Building
St. John's, Newfoundland
TEL: 737-3093

Mr. G. Howden
Chief Regional Planner (West)
Urban and Rural Planning Div.
Dept. Municipal Affairs & Housing
Confederation Building
St. John's, Newfoundland
TEL: 737-3087

Mr. D.G. Hustins
Director, Parks Division
Department of Tourism
Building 1045, Pleasantville
P.O. Box 9340
St. John's, Newfoundland
A1A 2Y3
TEL: 737-2424

Mr. W.E. Mercer
Chief Biologist
Wildlife Division
Department of Tourism
Building 810, Pleasantville
St. John's, Newfoundland
A1A 1P9
TEL: 737-2540

Mr. Wayne Pierce
Senior Project Biologist
Environmental Protection Service
Northwest Atlantic Fisheries Center
P.O. Box 5037
St. John's, Newfoundland
A1C 5V3
TEL: 737-5488

Mr. D. Slade
Director of Economic Research & Analysis
Cabinet Secretariat
Executive Council
Confederation Building
St. John's, Newfoundland
A1C 5T7
TEL: 737-2913

Ms. Jane Sproull-Thomson
Curator, Archaeology/Ethnology
Historic Resources Division
Department of Tourism
Newfoundland Museum
St. John's, Newfoundland
A1C 5T7
TEL: 737-2461

Mr. R. Warren
Director
Land Management Division
Dept. of Forest Resources & Lands
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7
TEL: 754-0090

Mr. D. Vanderveer
Senior Geologist
Environmental Geology Section
Mineral Lands & Mines Division
Department of Mines and Energy
Eastern Canada Building
St. John's, Newfoundland
TEL: 737-2750